



# Mark Scheme (Results)

January 2024

Pearson Edexcel International Advanced Level  
In Statistics S3 (WST03) Paper 01

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## General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

## General Instructions for Marking

The total number of marks for the paper is 75.

Edexcel Mathematics mark schemes use the following types of marks:

### 'M' marks

These are marks given for a correct method or an attempt at a correct method. In Mechanics they are usually awarded for the application of some mechanical principle to produce an equation, e.g. resolving in a particular direction; taking moments about a point; applying a suvat equation; applying the conservation of momentum principle; etc.

The following criteria are usually applied to the equation. To earn the M mark, the equation

- (i) should have the correct number of terms
- (ii) each term needs to be dimensionally correct

For example, in a moments equation, every term must be a 'force x distance' term or 'mass x distance', if we allow them to cancel 'g' s.

For a resolution, all terms that need to be resolved (multiplied by sin or cos) must be resolved to earn the M mark.

'M' marks are sometimes dependent (DM) on previous M marks having been earned, e.g. when two simultaneous equations have been set up by, for example, resolving in two directions and there is then an M mark for solving the equations to find a particular quantity – this M mark is often dependent on the two previous M marks having been earned.

### 'A' marks

These are dependent accuracy (or sometimes answer) marks and can only be awarded if the previous M mark has been earned. e.g. M0 A1 is impossible.

### 'B' marks

These are independent accuracy marks where there is no method (e.g. often given for a comment or for a graph).

A and B marks may be f.t. – follow through – marks.

## General Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes:

- bod means benefit of doubt
- ft means follow through
  - the symbol  $\surd$  will be used for correct ft
- cao means correct answer only
- cso means correct solution only, i.e. there must be no errors in this part of the question to obtain this mark
- isw means ignore subsequent working
- awrt means answers which round to

- SC means special case
- oe means or equivalent (and appropriate)
- dep means dependent
- indep means independent
- dp means decimal places
- sf means significant figures
- \* means the answer is printed on the question paper
- □ means the second mark is dependent on gaining the first mark

All A marks are 'correct answer only' (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.

For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected.

If a candidate makes more than one attempt at any question:

- If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
- If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.

Ignore wrong working or incorrect statements following a correct answer.

### **Special notes for marking Statistics exams (for AAs only)**

- Any correct method should gain credit. If you cannot see how to apply the mark scheme but believe the method to be correct then please send to review.
- For method marks, we generally allow or condone a slip or transcription error if these are seen in an expression. We do not, however, condone or allow these errors in accuracy marks.

| Question Number                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Scheme                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Marks                               |                                      |                                      |                 |           |                                     |                                      |                                      |        |                                   |                                     |                                     |    |       |            |            |    |     |            |            |   |       |            |           |   |       |            |           |         |  |          |            |     |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|--------------------------------------|--------------------------------------|-----------------|-----------|-------------------------------------|--------------------------------------|--------------------------------------|--------|-----------------------------------|-------------------------------------|-------------------------------------|----|-------|------------|------------|----|-----|------------|------------|---|-------|------------|-----------|---|-------|------------|-----------|---------|--|----------|------------|-----|
| 1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | $H_0$ : There is no association between treatment and presence of fungus<br>$H_1$ : There is association between treatment and presence of fungus                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | B1                                  |                                      |                                      |                 |           |                                     |                                      |                                      |        |                                   |                                     |                                     |    |       |            |            |    |     |            |            |   |       |            |           |   |       |            |           |         |  |          |            |     |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | <table><tr><td>Expected</td><td>No treatment</td><td>Sulphur</td><td>Copper sulphate</td></tr><tr><td>No Fungus</td><td><math>\frac{123 \times 30}{150} [=24.6]</math></td><td><math>\frac{123 \times 63}{150} [=51.66]</math></td><td><math>\frac{123 \times 57}{150} [=46.74]</math></td></tr><tr><td>Fungus</td><td><math>\frac{27 \times 30}{150} [=5.4]</math></td><td><math>\frac{27 \times 63}{150} [=11.34]</math></td><td><math>\frac{27 \times 57}{150} [=10.26]</math></td></tr></table>                                                                                                                                                      | Expected                            | No treatment                         | Sulphur                              | Copper sulphate | No Fungus | $\frac{123 \times 30}{150} [=24.6]$ | $\frac{123 \times 63}{150} [=51.66]$ | $\frac{123 \times 57}{150} [=46.74]$ | Fungus | $\frac{27 \times 30}{150} [=5.4]$ | $\frac{27 \times 63}{150} [=11.34]$ | $\frac{27 \times 57}{150} [=10.26]$ | M1 |       |            |            |    |     |            |            |   |       |            |           |   |       |            |           |         |  |          |            |     |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Expected                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | No treatment                        | Sulphur                              | Copper sulphate                      |                 |           |                                     |                                      |                                      |        |                                   |                                     |                                     |    |       |            |            |    |     |            |            |   |       |            |           |   |       |            |           |         |  |          |            |     |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | No Fungus                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | $\frac{123 \times 30}{150} [=24.6]$ | $\frac{123 \times 63}{150} [=51.66]$ | $\frac{123 \times 57}{150} [=46.74]$ |                 |           |                                     |                                      |                                      |        |                                   |                                     |                                     |    |       |            |            |    |     |            |            |   |       |            |           |   |       |            |           |         |  |          |            |     |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Fungus                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | $\frac{27 \times 30}{150} [=5.4]$   | $\frac{27 \times 63}{150} [=11.34]$  | $\frac{27 \times 57}{150} [=10.26]$  |                 |           |                                     |                                      |                                      |        |                                   |                                     |                                     |    |       |            |            |    |     |            |            |   |       |            |           |   |       |            |           |         |  |          |            |     |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | <table><tr><td>Observed</td><td>Expected</td><td><math>\frac{(O - E)^2}{E}</math></td><td><math>\frac{O^2}{E}</math></td></tr><tr><td>20</td><td>24.6</td><td>0.86016...</td><td>16.2601...</td></tr><tr><td>55</td><td>51.66</td><td>0.21594...</td><td>58.5559...</td></tr><tr><td>48</td><td>46.74</td><td>0.03396...</td><td>49.2939...</td></tr><tr><td>10</td><td>5.4</td><td>3.91851...</td><td>18.5185...</td></tr><tr><td>8</td><td>11.34</td><td>0.98373...</td><td>5.6437...</td></tr><tr><td>9</td><td>10.26</td><td>0.15473...</td><td>7.8947...</td></tr><tr><td colspan="2">Totals:</td><td>6.167...</td><td>156.167...</td></tr></table> | Observed                            | Expected                             | $\frac{(O - E)^2}{E}$                | $\frac{O^2}{E}$ | 20        | 24.6                                | 0.86016...                           | 16.2601...                           | 55     | 51.66                             | 0.21594...                          | 58.5559...                          | 48 | 46.74 | 0.03396... | 49.2939... | 10 | 5.4 | 3.91851... | 18.5185... | 8 | 11.34 | 0.98373... | 5.6437... | 9 | 10.26 | 0.15473... | 7.8947... | Totals: |  | 6.167... | 156.167... | dM1 |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Observed                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Expected                            | $\frac{(O - E)^2}{E}$                | $\frac{O^2}{E}$                      |                 |           |                                     |                                      |                                      |        |                                   |                                     |                                     |    |       |            |            |    |     |            |            |   |       |            |           |   |       |            |           |         |  |          |            |     |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 20                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 24.6                                | 0.86016...                           | 16.2601...                           |                 |           |                                     |                                      |                                      |        |                                   |                                     |                                     |    |       |            |            |    |     |            |            |   |       |            |           |   |       |            |           |         |  |          |            |     |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 55                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 51.66                               | 0.21594...                           | 58.5559...                           |                 |           |                                     |                                      |                                      |        |                                   |                                     |                                     |    |       |            |            |    |     |            |            |   |       |            |           |   |       |            |           |         |  |          |            |     |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 48                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 46.74                               | 0.03396...                           | 49.2939...                           |                 |           |                                     |                                      |                                      |        |                                   |                                     |                                     |    |       |            |            |    |     |            |            |   |       |            |           |   |       |            |           |         |  |          |            |     |
| 10                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 5.4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 3.91851...                          | 18.5185...                           |                                      |                 |           |                                     |                                      |                                      |        |                                   |                                     |                                     |    |       |            |            |    |     |            |            |   |       |            |           |   |       |            |           |         |  |          |            |     |
| 8                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 11.34                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 0.98373...                          | 5.6437...                            |                                      |                 |           |                                     |                                      |                                      |        |                                   |                                     |                                     |    |       |            |            |    |     |            |            |   |       |            |           |   |       |            |           |         |  |          |            |     |
| 9                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 10.26                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 0.15473...                          | 7.8947...                            |                                      |                 |           |                                     |                                      |                                      |        |                                   |                                     |                                     |    |       |            |            |    |     |            |            |   |       |            |           |   |       |            |           |         |  |          |            |     |
| Totals:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 6.167...                            | 156.167...                           |                                      |                 |           |                                     |                                      |                                      |        |                                   |                                     |                                     |    |       |            |            |    |     |            |            |   |       |            |           |   |       |            |           |         |  |          |            |     |
| $X^2 = \sum \frac{(O - E)^2}{E} \quad \text{or} \quad \sum \frac{O^2}{E} - 150$<br>= awrt 6.17<br>$\nu = (3 - 1)(2 - 1) = 2$<br>$\chi^2_2(0.05) = 5.991$<br>[Reject $H_0$ /significant/in the CR] There is sufficient evidence to suggest there is an association between <u>treatment</u> and presence of <u>fungus</u> .                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | dM1<br><br>A1<br>B1<br>B1ft<br><br>A1ft                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                     |                                      |                                      |                 |           |                                     |                                      |                                      |        |                                   |                                     |                                     |    |       |            |            |    |     |            |            |   |       |            |           |   |       |            |           |         |  |          |            |     |
| <b>Notes</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | <b>[8]</b>                          |                                      |                                      |                 |           |                                     |                                      |                                      |        |                                   |                                     |                                     |    |       |            |            |    |     |            |            |   |       |            |           |   |       |            |           |         |  |          |            |     |
| <p>1<sup>st</sup> B1 both hypotheses correct with treatment (oe) and fungus (oe) (treatment and fungus need to only appear in either <math>H_0</math> or <math>H_1</math>). May be written in terms of independence.</p> <p>1<sup>st</sup> M1 attempt at <math>\frac{\text{row total} \times \text{column total}}{\text{total}}</math> (can be implied by at least one correct <math>E_i</math> to 1dp)</p> <p>2<sup>nd</sup> M1 (dep on 1<sup>st</sup> M1) at least 2 correct terms for <math>\frac{(O - E)^2}{E}</math> or <math>\frac{O^2}{E}</math> or correct expressions with their <math>E_i</math> (allow 2sf accuracy) (May be implied by awrt 6.17 or awrt 156.17)</p> <p>3<sup>rd</sup> M1 (dep on 2<sup>nd</sup> M1) for using <math>\sum \frac{(O - E)^2}{E}</math> or <math>\sum \frac{O^2}{E} - 150</math> (May be implied by awrt 6.17)</p> <p>1<sup>st</sup> A1 awrt 6.17</p> <p>2<sup>nd</sup> B1 DoF/<math>\nu = 2</math> (May be implied by 5.991)</p> <p>3<sup>rd</sup> B1ft 5.991 (or better) allow ft from their stated degrees of freedom)</p> <p>2<sup>nd</sup> A1ft (dep on 3<sup>rd</sup> M1 and 3<sup>rd</sup> B1) for a correct ft contextualised conclusion. Must include “treatment” and “fungus”. Ignore any non-contextual statements. If hypotheses are the wrong way round then A0.</p> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                     |                                      |                                      |                 |           |                                     |                                      |                                      |        |                                   |                                     |                                     |    |       |            |            |    |     |            |            |   |       |            |           |   |       |            |           |         |  |          |            |     |

| Question Number | Scheme                                                                                                                                                                                                                               | Marks                   |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|
| 2. (a)          | <b>Number</b> all employees [1-800]<br>Use a <b>random</b> number to select the <b>first employee</b> oe<br>Then select every <b>10<sup>th</sup></b> employee from the list of employees                                             | B1<br>B1<br>B1<br>(3)   |
| (b)             | <b>Number</b> all employees <b>by city/for each city</b><br>Use <b>random</b> numbers to select<br><b>54</b> employees from London, <b>31</b> employees from Edinburgh and <b>15</b> employees from Cardiff                          | B1<br>B1<br>B1<br>(3)   |
| (c)             | e.g Stratified sample reflects the population structure                                                                                                                                                                              | B1<br>(1)<br><b>[7]</b> |
| <b>Notes</b>    |                                                                                                                                                                                                                                      |                         |
| (a)             | 1 <sup>st</sup> B1 idea of <b>numbering</b> all employees<br>2 <sup>nd</sup> B1 idea of <b>randomly</b> selecting a starting point<br>3 <sup>rd</sup> B1 selecting every <b>k<sup>th</sup></b> employee                              |                         |
| (b)             | 1 <sup>st</sup> B1 idea of <b>numbering</b> employees for <b>each city</b><br>2 <sup>nd</sup> B1 use of <b>random</b> numbers (oe)<br>3 <sup>rd</sup> B1 <b>54</b> from London, <b>31</b> from Edinburgh, <b>15</b> from Cardiff cao |                         |
| (c)             | Any correct advantage e.g. Allows calculations [of statistics] for each city/group                                                                                                                                                   |                         |

| Question Number | Scheme                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Marks                               |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |         |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |                                  |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|---|---|---|---|---|---|---|--------|---|---|---|---|---|---|---|--------|---|---|---|---|---|---|---|---------|---|---|---|---|---|---|---|--------|---|---|---|---|---|---|---|--------|---|---|---|---|---|---|---|----------------------------------|
| 3. (a)          | $H_0 : \rho = 0$ $H_1 : \rho \neq 0$<br>$[r =] \frac{83.634}{\sqrt{2.486 \times 3026.234}} = 0.9642.....$ awrt 0.964<br>CV = 0.7545<br>[Reject $H_0$ /Significant] There is evidence of correlation between annual <u>tea consumption</u> and <u>population</u> .                                                                                                                                                                                                                                                                                                                                                                                                                                                          | B1<br>M1 A1<br>B1ft<br>A1<br>(5)    |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |         |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |                                  |
| (b)             | <table><tr><td>Country</td><td>A</td><td>B</td><td>C</td><td>D</td><td>E</td><td>F</td><td>G</td></tr><tr><td>T Rank</td><td>5</td><td>6</td><td>4</td><td>7</td><td>1</td><td>2</td><td>3</td></tr><tr><td>P Rank</td><td>7</td><td>6</td><td>4</td><td>3</td><td>1</td><td>2</td><td>5</td></tr></table> or<br><table><tr><td>Country</td><td>A</td><td>B</td><td>C</td><td>D</td><td>E</td><td>F</td><td>G</td></tr><tr><td>T Rank</td><td>3</td><td>2</td><td>4</td><td>1</td><td>7</td><td>6</td><td>5</td></tr><tr><td>P Rank</td><td>1</td><td>2</td><td>4</td><td>5</td><td>7</td><td>6</td><td>3</td></tr></table> $\sum d^2 = 4+0+0+16+0+4 [= 24]$<br>$[r_s =] 1 - \frac{6(24)}{7(48)} = 0.571428...$ awrt 0.571 | Country                             | A | B | C | D | E | F | G | T Rank | 5 | 6 | 4 | 7 | 1 | 2 | 3 | P Rank | 7 | 6 | 4 | 3 | 1 | 2 | 5 | Country | A | B | C | D | E | F | G | T Rank | 3 | 2 | 4 | 1 | 7 | 6 | 5 | P Rank | 1 | 2 | 4 | 5 | 7 | 6 | 3 | M1<br><br><br>M1<br>dM1A1<br>(4) |
| Country         | A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | B                                   | C | D | E | F | G |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |         |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |                                  |
| T Rank          | 5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 6                                   | 4 | 7 | 1 | 2 | 3 |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |         |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |                                  |
| P Rank          | 7                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 6                                   | 4 | 3 | 1 | 2 | 5 |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |         |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |                                  |
| Country         | A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | B                                   | C | D | E | F | G |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |         |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |                                  |
| T Rank          | 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 2                                   | 4 | 1 | 7 | 6 | 5 |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |         |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |                                  |
| P Rank          | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 2                                   | 4 | 5 | 7 | 6 | 3 |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |         |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |                                  |
| (c)             | $H_0 : \rho_s = 0$ $H_1 : \rho_s > 0$<br>CV = 0.7143<br>[Do not reject $H_0$ / not significant] There is not enough evidence to suggest a <u>positive</u> correlation between annual <u>tea consumption</u> and <u>population</u> .                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | B1<br>M1<br><br>A1ft<br>(3)<br>[12] |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |         |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |                                  |
| Notes           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                     |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |         |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |                                  |
| (a)             | 1 <sup>st</sup> B1 both hypotheses correct in terms of $\rho$ (must be two-tailed). Condone use of $p$<br>M1 use of formula for $r$ (May be implied by awrt 0.964)<br>1 <sup>st</sup> A1 awrt 0.964<br>2 <sup>nd</sup> B1ft 0.7545 (or better) or ft 1-tailed alternative hypothesis (0.6694)<br>2 <sup>nd</sup> A1 correct contextual conclusion including tea consumption/ $t$ and population/ $p$ . Must be consistent with their $r$ and their CV. (Ignore any non-contextual conclusion)<br>Allow positive correlation                                                                                                                                                                                                |                                     |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |         |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |                                  |
| (b)             | 1 <sup>st</sup> M1 attempt to rank each country for tea and population (at least 4 correct in each)<br>2 <sup>nd</sup> M1 for $\sum d^2$ for their ranks (implied by $\sum d^2 = 24$ )<br>2 <sup>nd</sup> M1 (dep on 1 <sup>st</sup> M1) use of $1 - \frac{6(24)}{7(48)}$<br><br>A1 awrt 0.571 (or $\frac{4}{7}$ )                                                                                                                                                                                                                                                                                                                                                                                                         |                                     |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |         |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |                                  |
| (c)             | B1 both hypotheses correct in terms of $\rho$ or $\rho_s$ . Condone use of $p$<br>M1 0.7143 (or better)<br>A1ft correct contextual conclusion including positive, tea consumption/ $t$ and population/ $p$ . (Ignore any non-contextual conclusion) ft their part (b)                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                     |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |         |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |                                  |

| Question Number | Scheme                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Marks                                        |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------|
| 4. (a)          | $\frac{[0 \times 24] + 1 \times 34 + 2 \times 28 + 3 \times 21 + 4 \times 8 + 5 \times 5}{120} [= 1.75]^*$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | B1*cs0<br>(1)                                |
| (b)             | $[s = ]120 \times \frac{e^{-1.75} 1.75^4}{4!} [= 8.15]^*$ <p>or</p> $[s = ]120 - \left( 20.85 + 36.49 + 31.93 + 120 \times \frac{e^{-1.75} 1.75^3}{3!} + 3.95 \right) [= 8.15]^*$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | B1*cs0<br>(1)                                |
| (c)             | $[r = ]18.63$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | B1<br>(1)                                    |
| (d)             | <p><math>H_0</math> : Poisson distribution is a good fit.<br/> <math>H_1</math> : Poisson distribution is not a good fit</p> $\sum \frac{(O_i - E_i)^2}{E_i} = 1.43 + \frac{(8 + 5 - (8.15 + 3.95))^2}{8.15 + 3.95}$ <p style="text-align: right;"><math>= 1.49694... \text{ awrt } 1.5(0)</math></p> <p><math>\nu = 5 - 1 - 1 = 3</math><br/> <math>\chi^2_3(0.05) = 7.815</math><br/> [Do not reject <math>H_0</math>/not significant]<br/> There is insufficient evidence to reject the office manager's belief or the number of jobs sent to the printer are consistent with a Poisson distribution.</p>                                                                                                                                                                                                                                                                                                                   | B1<br>M1 M1<br>A1<br>B1<br>B1ft<br>A1<br>(7) |
| <b>[10]</b>     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                              |
| <b>Notes</b>    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                              |
| (a)             | B1cso correct calculation, minimum working $\frac{34 + 56 + 63 + 32 + 25}{120} = 1.75^*$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                              |
| (b)             | B1cso fully correct calculation (may be seen in stages) leading to 8.15*                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                              |
| (c)             | For 18.63 (This may be seen in part (b) if labelled as $r$ )                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                              |
| (d)             | 1 <sup>st</sup> B1 both hypotheses correct (mention of 1.75 is B0)<br>1 <sup>st</sup> M1 evidence of combining last 2 cells e.g. 8 + 5 and 8.15 + 3.95<br>2 <sup>nd</sup> M1 use of $1.43 + \sum \frac{(O_i - E_i)^2}{E_i}$ for remaining cells (Condone cells not combined. May be implied by $1.43 + 0.00276... + 0.279... \text{ or awrt } 1.71$ )<br>1 <sup>st</sup> A1 awrt 1.50 (allow 1.5 from correct working)<br>2 <sup>nd</sup> B1 Dof/ $\nu = 3$ implied by a correct critical value of 7.815<br>3 <sup>rd</sup> B1ft 7.815 (allow ft on the $\nu$ so may see 9.488 or 11.070 etc)<br>2 <sup>nd</sup> A1 (dep on 2 <sup>nd</sup> M1) a correct conclusion which states that the office manager's belief is correct/the data are consistent with a Poisson distribution which must be consistent with the test statistic and CV.<br>Condone Po(1.75) is a suitable model. This mark is independent of the hypotheses |                                              |

| Question Number | Scheme                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Marks                                                  |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------|
| 5. (a)          | $H_0 : \mu_H - \mu_M = 15$ $H_1 : \mu_H - \mu_M > 15$<br><br>$z = \frac{56.3 - 39.8 - 15}{\sqrt{\frac{27.2}{38} + \frac{18.5}{45}}}$ $= 1.4130\dots$ <p style="text-align: right;">awrt 1.41</p> CV = 1.6449 (or better) or $p = \text{awrt } 0.0788$<br>Do not reject $H_0$ /Not significant<br>There is not sufficient evidence to support the <u>professor's claim</u> /there is not sufficient evidence to suggest that undergraduates studying <u>History type</u> more than 15 words/minute faster than undergraduates studying <u>Maths</u> .                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | B1<br><br>M1 M1<br><br>A1<br>B1<br>M1<br><br>A1<br>(7) |
| (b)             | $s^2 \approx \sigma^2$ for <b>both</b> History and Maths<br>Assume sample sizes are large enough so that CLT applies or $\bar{X}$ is normally distributed for <b>both</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | B1<br>B1<br>(2)<br><b>[9]</b>                          |
| <b>Notes</b>    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                        |
| (a)             | 1 <sup>st</sup> B1 both hypotheses correct in terms of $\mu_H$ and $\mu_M$ Allow equivalent rearrangements.<br>Allow other letters as long it is clear which is History and which is Maths<br>Must be attached to $H_0$ and $H_1$<br><br>1 <sup>st</sup> M1 for $z = \frac{a - b - 15}{\sqrt{\frac{c}{38} + \frac{d}{45}}}$ with at least 2 of $a, b, c$ or $d$ correct (allow $\pm$ )<br><br>2 <sup>nd</sup> M1 for $z = \frac{56.3 - 39.8 - 15}{\sqrt{\frac{27.2}{38} + \frac{18.5}{45}}}$ (allow $\pm$ )<br><br>1 <sup>st</sup> A1 awrt 1.41<br>2 <sup>nd</sup> B1 for CV = $\pm 1.6449$ and compatible sign with their test statistic (allow $p = \text{awrt } 0.0788$ )<br>3 <sup>rd</sup> M1 correct statement consistent with their test statistic and CV (no contradictory non-contextual comments) May be implied by correct contextual comment.<br>2 <sup>nd</sup> A1 contextual conclusion that is consistent with their test statistic and their CV. Must mention professor's claim or History, Maths and typing (oe). |                                                        |
| (b)             | 1 <sup>st</sup> B1 must mention both. Allow $s \approx \sigma$ for both History and Maths<br>2 <sup>nd</sup> B1 either correct assumption                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                        |

| Question Number | Scheme                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Marks                                                       |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|
| 6. (a)          | $[\bar{x} = 49.8]$ <div> <math>2 \times 1.96 \left( \frac{\sigma}{\sqrt{8}} \right) = 53.88 - 45.72 = 8.16</math> <math>2 \times 2.5758 \left( \frac{\sigma}{\sqrt{8}} \right) = \frac{8.16 \times 2.5758}{1.96} = 10.7238...</math> <math>99\% \text{CI} = 49.8 \pm \frac{10.7238}{2}</math> </div> <div> <math>49.8 + 1.96 \left( \frac{\sigma}{\sqrt{8}} \right) = 53.88 \text{ or}</math> <math>49.8 - 1.96 \left( \frac{\sigma}{\sqrt{8}} \right) = 45.72</math> <math>2.5758 \left( \frac{\sigma}{\sqrt{8}} \right) = \frac{4.08 \times 2.5758}{1.96} = 5.3618...</math> <math>99\% \text{CI} = 49.8 \pm 5.3618</math> </div> <div> <math>= (44.438..., 55.1619...) \quad (\text{awrt } 44.4, \text{ awrt } 55.2)</math> </div>                                                                            | M1<br><br>B1 M1<br>M1<br>A1 (5)                             |
| (b)             | $\hat{\mu} = \bar{x} = \frac{91.2}{8} = 11.4$ $\hat{\sigma}^2 = s^2 = \frac{1145.16 - 8 \times "11.4^2"}{7} = 15.06857...$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | B1<br><br>M1<br>A1 (3)                                      |
| (c)             | <p>Combined <math>\Sigma x = 10.8 \times 24 + 91.2 = 350.4</math><br/> Combined <math>\Sigma x^2 = 1145.16 + 23 \times 17.64 + 24 \times 10.8^2 = 4350.24</math></p> $\text{Combined } s^2 = \frac{"4350.24" - 32 \times \left( \frac{"350.4"}{32} \right)^2}{31} = 16.56$ $\frac{s}{\sqrt{n}} = \frac{\sqrt{16.56}}{\sqrt{32}} = 0.719374...$                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | M1<br>A1<br>M1<br>M1A1<br><br>M1 A1<br>M1 A1<br>(7)<br>[15] |
| <b>Notes</b>    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                             |
| (a)             | <p>1<sup>st</sup> M1 use of <math>2z \frac{\sigma}{\sqrt{n}}</math> or <math>z \frac{\sigma}{\sqrt{n}}</math> with <math>1.5 &lt;  z  &lt; 2</math>. Allow <math>\sigma_m</math> for <math>\frac{\sigma}{\sqrt{n}}</math><br/> B1 1.96 (or better) and 2.5758 (or better)<br/> 2<sup>nd</sup> M1 attempt to find width or semi-width of 99% CI with <math> z  &gt; 2</math> Allow <math>\sigma = \frac{4.08 \times \sqrt{8}}{1.96} [= 5.887...]</math><br/> 3<sup>rd</sup> M1 Use of <math>49.8 \pm \text{awrt } 5.36</math> or <math>49.8 \pm 2.5758 \left( \frac{"5.887..."}{\sqrt{8}} \right)</math> If <math>\sigma</math> is incorrect then working must be shown.<br/> A1 correct interval with (awrt 44.4, awrt 55.2)<br/> Correct answer from less accurate <math>z</math> -values scores M1B0M1M1A1</p> |                                                             |
| (b)             | <p>B1 11.4 cao<br/> M1 full attempt at <math>s^2</math> ft their <math>\bar{x}</math><br/> A1 awrt 15.1</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                             |
| (c)             | <p>M1 for correct combined sum (may be implied by combined mean of 10.95)<br/> 2<sup>nd</sup> M1 for attempt at combined sum of squares <math>1145.16 + (n - 1) \times 17.64 + n \times 10.8^2</math> (allow 1 error)<br/> 1<sup>st</sup> A1 fully correct expression or awrt 4350<br/> 3<sup>rd</sup> M1 using their values in a complete expression for combined <math>s^2</math> oe<br/> 2<sup>nd</sup> A1 <math>s^2 = 16.56</math> or <math>s = \text{awrt } 4.07</math> (either of these implies M1M1A1M1A1)<br/> 4<sup>th</sup> M1 use of <math>\frac{s}{\sqrt{n}}</math> with combined values<br/> 3<sup>rd</sup> A1 awrt 0.719</p>                                                                                                                                                                       |                                                             |

| Question Number | Scheme                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Marks                                          |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------|
| 7. (a)          | $a = 2 \times 180 - 330 = 30$<br>$b = 4.5^2 \times 2 + 6.7^2 = 85.39$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | B1<br>M1 A1<br>(3)                             |
| (b)             | $X = L - 1.8S$<br>$E(X) = 330 - 1.8 \times 180 = 6$<br>$\text{Var}(X) = 6.7^2 + 1.8^2 \times 4.5^2 = 110.5$<br>$P(X > 0) = P\left(Z > \frac{0-6}{\sqrt{110.5}}\right)$<br>$P(Z > -0.57) = 0.7157$                                                                                                                                                                                                                                                                                                                                                                | M1<br>M1 A1<br><br>M1<br>A1<br>(5)             |
| (c)             | $T = S_1 - \frac{S_1 + S_2 + S_3}{3} = \frac{2S_1 - S_2 - S_3}{3}$<br>$E(T) = 0$<br>$\text{Var}(T) = \frac{1}{9}(2^2 \times 4.5^2 + 4.5^2 + 4.5^2) = \frac{6}{9}(4.5^2) = 13.5$<br>$P(T > 5) = P\left(Z > \frac{5-0}{\sqrt{13.5}}\right)$<br>$P(Z > 1.36) = 1 - 0.9131 = 0.0869$                                                                                                                                                                                                                                                                                 | M1 A1<br>M1<br><br>M1<br><br>A1<br>(6)<br>[14] |
| Notes           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                |
| (a)             | B1 30 cao<br>M1 $2 \times \text{Var}(S) + \text{Var}(L)$<br>A1 85.39 (allow 85.4)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                |
| (b)             | 1 <sup>st</sup> M1 Seeing or using $E(X) = 6$ or correct expression for mean<br>2 <sup>nd</sup> M1 $\text{Var}(L) + 1.8^2 \text{Var}(S)$ (condone mixing variances for M1)<br>1 <sup>st</sup> A1 for 110.5 (allow 65.61 + 6.7 <sup>2</sup> )<br>3 <sup>rd</sup> M1 standardising with their mean and s.d. leading to a probability $p > 0.5$<br>2 <sup>nd</sup> A1 awrt 0.716 [calc: 0.7159262...]                                                                                                                                                               |                                                |
| (c)             | 1 <sup>st</sup> M1 realising the need to write as a single distribution using $\bar{S} = \frac{S_1 + S_2 + S_3}{3}$<br>1 <sup>st</sup> A1 for $\frac{2S_1 - S_2 - S_3}{3}$<br>2 <sup>nd</sup> M1 Using mean = 0<br>3 <sup>rd</sup> M1 using $\text{Var}(aS) = a^2 \text{Var}(S)$<br>4 <sup>th</sup> M1 standardising with their mean and sd<br>2 <sup>nd</sup> A1 awrt 0.0868 to awrt 0.0869 [calc: 0.08678...]<br>Note: Assuming $S_1$ and $\bar{S}$ are independent, leads to $E(T) = 0$ , $\text{Var}(T) = 27$ , $P(T > 5) = 0.167...$<br>scores M0A0M1M0M1A0 |                                                |

