Version

**General Certificate of Education (A-level)**
**January 2013**

# Statistics SS03

# (Specification 6380)

# Statistics 3

# Final

# *Mark Scheme*

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**Key to mark scheme abbreviations**

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

**No Method Shown**

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

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

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

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

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

| Q | Solution | Marks | Total | Comments |
|---|---|---|---|---|
| 1 | $H_o$ Outcome of loan is independent of recipient<br>$H_1$ Outcome of loan is not independent of recipient | B1 | | both |
| | 1 tail 5% | | | |
| | **Exp** — **Ind** / **Small bus** / **Large bus**<br>**Satisfac** — 39.72 / 60.38 / 42.9<br>**Bad debt** — 10.28 / 15.62 / 11.11 | M1<br>A1 | | For E method<br>For 3 or more correct |
| | ts = $\sum \frac{(O-E)^2}{E}$ | m1 | | For ts method |
| | = $\frac{0.28^2}{39.72}+\frac{5.38^2}{60.38}+\frac{5.1^2}{42.9}+\frac{0.28^2}{10.28}+\frac{5.38^2}{15.62}+\frac{5.1^2}{11.1}$ | A1 | | 5.20 – 5.40 |
| | = 5.29 | B1 | | B1 cv correct |
| | 5% df =2 cv = 9.21<br>ts < 9.21 | A1 | | |
| | Accept $H_o$ | | | |
| | No sig evidence to suggest that the outcome of the loan is associated with ( not independent of) the type of recipient | E1 | 8 | In context |
| | **Total** | | **8** | |

| Q | Solution | Marks | Total | Comments |
|---|---|---|---|---|
| **2(a)** | Sibling pairs were used in order to eliminate any individual differences between students so that any difference due to birthdate is more likely to be detected, if one exists. | E1<br><br>E1 | 2 | 'Student effect' eliminated<br><br>More likely to detect any difference |
| **(b)** | Ho $\eta_d = 0$<br>H1 $\eta_d > 0$<br>1 tail test 10 % level | B1 | | For both |
| | Signs<br>+ + + + + + - - +<br>test stat 7+ / 2 –<br>B ( 9, 0.5 ) model<br>P( ≥ 7+ ) = P( ≤ 2 - ) = 0.090(0.0898)<br><br>0.090 < 0.10 | M1A1<br><br>M1<br><br>M1 | | For signs<br>Correct ts<br>Use of B (9, 0.5)<br><br>Correct comparison |
| | Significant evidence to reject Ho. There is significant evidence to suggest that, on average in Year 7, students with autumn birthdays gain higher CAT scores than those with summer birthdays . | E1 | 6 | Correct conclusion in context |
| | **Total** | | **8** | |

| Q | Solution | Marks | Total | Comments |
|---|---|---|---|---|
| 3 | $H_o$ $\mu_d$ , $\eta_d$ = 0<br>$H_1$ $\mu_d$ , $\eta_d$ > 0 1 tail 5% | B1 | | Or equivalent in words |
| | diffs 4 6 2 -3 -1 3 5 7<br>rank 5 7 2 3½ 1 3½ 6 8 | M1<br>m 1 | | For differences<br>Ranks |
| | $T_+$ = 5 + 7 + 2 + 3½ + 6 + 8=31½<br>$T_-$ = 3½ + 1 = 4½ | m1<br>A1 | | Total of ranks<br>One correct |
| | Test stat $T$ = 4½<br>$n$ = 8<br>cv = 6<br>$T$ < 6 | B1<br>m1 | | For cv<br>Correct comparison ts/cv with cv = 6,8,4 |
| | Reject $H_o$ | | | |
| | There is significant evidence to suggest that average taste score for a seafood dish is higher when sounds of the seaside are played. | E1 | 8 | In context |
| | **Total** | | **8** | |

| Q | Solution | Marks | Total | Comments |
|---|---|---|---|---|
| **4(a)** | | | | |
| | $H_0$ Samples from identical populations<br>$H_1$ Samples not from identical populations 5% sig level | B1 | | Or hypotheses referring to difference between at least 2 population averages |
| | Ranks | M1<br>A1 | | For ranks as one group<br>10 or more correct |
| | Totals of ranks | | | |
| | $T_P = 25$ $T_Q = 64$ $T_R = 31$<br>$n_P = 5$ $n_Q = 5$ $n_R = 5$ | m1 | | Totals can be reversed rank<br>$T_P = 55$ $T_Q = 16$ $T_R = 49$ |
| | $\sum_{i=1}^{m} \frac{T_i^2}{n_i} = \frac{25^2}{5} + \frac{64^2}{5} + \frac{31^2}{5} = 1136.4$ | m1<br>m1 | | Numerators correct<br>Denominators correct |
| | $H = \frac{12}{15 \times 16} \times 1136.4 - (3 \times 16)$<br>$= 8.82$ | m1<br>A1 | | H formula correctly used<br>AWFW (8.6, 9.1) |
| | Critical value from $\chi^2_2 = 5.991$<br>$H > 5.991$ | B1 | | For cv |
| | Reject $H_0$ Sig evidence to doubt that samples are from identical poulations. At least two average times differ for the 3 makes of urn | E1 | 10 | Conclusion correct in context |
| **(b)(i)** | A difference in average time taken for water to boil was found in part (a) so at least 2 urns differ. Urn Q had the lowest total/average time/ highest ranks so should be selected as Urn Q is significantly faster than Urn P. | E1<br>E1 | | Choosing Q<br>Clear reasoning<br>(can be lowest rank ft) |
| **(ii)** | Cost of purchasing/operating the urns<br>Ease of use of urns<br>Supplier availability<br>Cost of maintenance/reliability<br>Different sizes require | E1 | 3 | Sensible reason |
| | **Total** | | **13** | |

| P | Q | R |
|---|---|---|
| 1 | 10 | 2 |
| 3 | 12 | 5 |
| 4 | 13 | 7 |
| 6 | 14 | 8 |
| 11 | 15 | 9 |

| Q | Solution | Marks | Total | Comments |
|---|---|---|---|---|
| 5(a) | $H_o$ Samples are taken from identical populations<br>$H_1$ Samples are not taken from identical populations – population average level of impurity differs<br>2 tail 5% | B1 | | For both<br>or equivalent hypotheses referring to population medians. |
| | Ranks<br>A 1 2 3 6 8 9 10 11 12 14½<br>B 4 5 7 13 14½ 16 17 18 19 20 | M1<br>m1 | | Attempt at ranks as 1 group<br>10 correct as one group/ties |
| | $T_A = 1 + 2 + \ldots + 14½ = 76½$<br>$T_B = 4 + 5 + \ldots + 20 = 133½$ | m1 | | totals |
| | $U_A = 76.5 - \frac{10\times11}{2} = 21.5$<br>$U_B = 133.5 - \frac{10\times11}{2} = 78.5$ | m1 A1 | | U calculated<br>either correct |
| | Test stat U = 21.5<br>cv = 24<br>U < 24<br>Reject $H_o$<br>Significant evidence at the 5% level to suggest that there is a difference in the average level of impurity for processes A and B. | B1<br>A1<br><br>A1<br><br>E1 | <br><br><br><br>10 | cv correct<br>correct choice of ts U for comparison<br><br><br>In context |
| (b)(i) | | | | |
| | | M1<br>A1 | <br>2 | Either A or B freq correct<br>All correct |
| (ii) | $H_o$ Number of faults is independent of process<br>$H_1$ Number of faults is not independent of process.<br>1 tail 10% | B1 | | For both |
| | | M1<br>A1 | | For expected freq method<br>All correct to 1 dp (not integers) |
| | $ts = \sum \frac{(\lvert O-E\rvert - 0.5)^2}{E}$ $\lvert O - E\rvert = 2.64$<br>$= \frac{2.14^2}{7.36} + \frac{2.14^2}{8.64} + \frac{2.14^2}{38.64} + \frac{2.14^2}{45.36}$<br>= 1.37 | M1<br>m1<br><br>m1<br>A1 | | Ts effort denominator<br>Yate's effort<br><br>Correct 2.14 seen<br>AWFW (1.30, 1.42) |
| | df = 1 10% cv =2.706 ts < 2.706<br>Accept $H_o$ | B1<br>A1 | <br>9 | cv correct |
| (c) | Jess should choose process B since the test in part (a) indicates that process B results in a lower level of impurity and the test in part (b) indicates no significant evidence of a difference in fault levels between A and B | B1<br>E1 | <br>2 | <br>Choice B with reasons ref parts (a) and (b) |
| | **Total** | | **23** | |

| | A | B | total |
|---|---|---|---|
| **Fault** | 10 | 6 | 16 |
| **No fault** | 36 | 48 | 84 |
| **total** | 46 | 54 | 100 |

| | A | B | total |
|---|---|---|---|
| **Fault** | 7.36 | 8.64 | 16 |
| **No fault** | 38.64 | 45.36 | 84 |
| **total** | 46 | 54 | 100 |

| Q | Solution | Marks | Total | Comments |
|---|---|---|---|---|
| **6(a)** | Ranks | | | |

| | *Rank mother* | *Rank son* | *Rank d'ter* |
|---|---|---|---|
| **1** | 1 | 2 | 2 |
| **2** | 2 | 5½ | 1 |
| **3** | 3 | 1 | **4** |
| **4** | **4** | 5½ | **4** |
| **5** | **5** | 3 | **4** |
| **6** | **6½** | 8 | **6** |
| **7** | **6½** | 7 | **7** |
| **8** | **8** | 10 | **8** |
| **9** | 9 | 9 | 9 |
| **10** | 10 | 4 | 10 |

| Q | Solution | Marks | Total | Comments |
|---|---|---|---|---|
| | | M1 | | Any 3 correct ranks mother |
| | | M1 | | Any 3 correct ranks daughter |
| | | M1 | | Ties correct in any column |
| | | A1 | 4 | All correct |
| **(b)(i)** | $r_s$ = 0.598 ( 3 sig figs) | B2 | | Alt diffs $\lvert d \rvert$<br>1, 3½, 2, 1½, 2, 1½, ½, 2, 0,6<br>$\sum d^2 = 66$ M1<br>$r_s = 1 - \frac{6\times 66}{10\times 99} = 0.6$ A1 |
| **(ii)** | $r_s$ = 0.972 ( 3 sig figs) | B2 | 4 | Alt diffs $\lvert d \rvert$<br>1, 1, 1, 0, 1, ½, ½, 0, 0, 0,<br>$\sum d^2 = 4.5$ M1<br>$r_s = 1 - \frac{6\times 4.5}{10\times 99} = 0.973$ A1 |
| **(c)(i)(ii)** | $H_O$ no assoc in ranks in population between mother and son/daughter<br>$H_1$ positive assoc in ranks in population between mother and son/daughter | B1 | | or equivalent<br>for both |
| | 1 tail test 1 % level<br>cv = 0.7333 | B1 | | for cv |
| | Mother/son ts $r_s$ = 0.598 < 0.7333 | M1 | | |
| | Accept $H_O$ | A1 | | conclusion correct |
| | Mother/daughter ts $r_s$ = 0.972 > 0.7333 | M1 | | |
| | Reject $H_O$ | A1 | | conclusion correct |
| | There is significant evidence of a positive correlation between number of years spent in full-time education for mother and daughter but no significant evidence of a positive correlation for mother and son. | E1 | 7 | |
| | **Total** | | **15** | |
| | **TOTAL** | | **75** | |