Version 1.0

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

# Statistics SS03

# (Specification 6380)

# Statistics 3

***Mark Scheme***

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

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**Key to mark scheme abbreviations**

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

**No Method Shown**

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

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

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

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

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

| Q | Solution | Marks | Total | Comments |
|---|---|---|---|---|
| **1(a)** | $H_0$ Population median purchases = 5<br>$H_1$ Population median purchases > 5<br>1 tail test 10% level<br>signs | B1 | | Pop can be implied if fully worded in context<br>oe $\eta$ not $\mu$ |
| | – + + + + + + + + – + – + | M1 | | for signs can be reversed or incorrect (WSR diff OK) |
| | test stat = 3– / 9+ | A1 | | for test stat 3 or 9 |
| | Bin (12, 0.5) model | M1 | | for use of Bin model<br>any B ( 12, 0.5) prob |
| | $P(\leq 3–) = 0.0730 < 0.10$ | M1 | | for comparison ts and 10% |
| | Reject $H_o$ Significant evidence to suggest median number of packets has increased | A1 | 6 | cr {0,1,2,3} or {9,10,11,12}<br>must see 0.0729/0.194 M1m1 |
| **(b)** | Wilcoxon signed-rank test | B1 | 1 | Just Wilcoxon |
| | **Total** | | **7** | |
| **2** | | | | |
| **(a)** | ranks<br>*x* 1, 3, 5, 6, 9, 10, 4, 2, 7, 8,<br>10, 8, 6, 5, 2, 1, 7, 9, 4, 3 | M1 | | for any ranks |
| | *y* 1, 3, 5, 7, 9, 10, 4, 2, 6, 8<br>10, 8, 6, 4, 2, 1, 7, 9, 5, 3 | M1<br>A1 | | 2 separate sets of ranks<br>All correct |
| | $r_s$ (from calculator) = 0.988 or 0.987<br>0.98/0.99 allow B2 if no method seen | B3 | 6 | alternatively<br>differences, $d$ : 0, 0, 0, 1, 0, 0, 0, 0, 1, 0<br>$\sum d^2 = 2$ M1 diffs<br>$r_s = 1 - \frac{6 \times 2}{10 \times 99} = 0.988$ or 0.987 M1, A1 |
| **(b)** | $H_0$ no association<br>$H_1$ positive association 1 tail 1% | B1 | | Allow $p/\rho = 0$ or words<br>Must be 1 tail |
| | test stat $r_s$ = 0.988<br>critical value = 0.7333<br>tests stat > 0.7333 so significant evidence exists to reject $H_o$ and conclude that a positive association exists. | B1<br>M1 | | for cv<br>comparison ts/cv; ft $r_s$ in (a)<br>0.7667,0.7818/0.6485/0.700<br>B0 M1 E0 |
| | This suggests that hurricanes in which there are higher numbers of injuries also result in a greater cost in property damage ( or positive assoc in context ) | E1 | 4 | explanation in context |
| **(c)(i)** | see scatter diagram | M1<br>A1 | 2 | 8+ points effort<br>plot OK (allow 1 small slip) |
| **(ii)** | There is evidence of a **non linear** relationship(or it is a curve) | B1 | 1 | Must mention no (straight) line fit |
| | **Total** | | **13** | |

| Q | Solution | Marks | Total | Comments |
|---|---|---|---|---|
| **3(a)** | $H_0$ Reaction is independent of eye colour<br>$H_1$ Reaction is not independent of eye colour<br>1 tail 5% | B1 | | $H_0$ independent /no assoc<br>$H_1$ not independent/assoc |
| | **Expected** / **Blue** / **Brown** / **Other**<br>**None** 19.33 12.00 8.67<br>**Mild** 21.75 13.50 9.75<br>**Strong** 16.92 10.50 7.58 | M1<br>M1<br>A1 | | Method for expected frequencies<br>One row/col correct<br>All correct to 1 dp (not integers but truncated OK) |
| | ts = $\sum \frac{(O-E)^2}{E}$<br>$= \frac{6.33^2}{19.33} + \frac{5^2}{12} + ..... + \frac{6.5^2}{10.5} + \frac{3.42^2}{7.58}$<br>2.07 + 2.08 + ..<br>= 13.45 | M1<br>A1 | | Numerator correct<br>Denominator correct both<br>ts correct ( 12.5 -14.5) |
| | cv df = 4 5% cv = 9.488 | B1 | | df = 4 row B0 M1 A0<br>(7.779,11.143,13.277,14.86) |
| | ts > 9.488<br>Reject $H_0$ | M1<br>A1 | | Or p=0.00925 < 0.05; ft on ts |
| | Sig evidence to suggest that skin reaction is not independent of eye colour. | E1 | 10 | In context ft conclusion |
| **(b)** | Brown-eyed people more likely than expected to have a'none' reaction ( or blue-eyed people less likely than expected to have a 'none'reaction) | | | |
| | Blue-eyed people more likely then expected to have a'strong' reaction ( or brown-eyed people less likely than expected to have a 'strong'reaction)<br>'Other' less likely than expected to have a mild reaction ( more likely to have a strong reaction) | B1<br>E1 | 2 | Any one of these comments ( ref none, mild or strong) acceptable – general idea correct<br>Fully explained.<br>Must mention more/less than <u>expected</u><br>Not dep on (a) |
| | **Total** | | **12** | |

| Q | Solution | Marks | Total | Comments |
|---|---|---|---|---|
| **4(a)** | Ranks<br>**A** 3, 4, 7, 9, 10<br>**B** 1, 2, 6, **11**, **12½**<br>**C** 8, **12½**, **15**, **17**, **18**<br>**D** 5, **14**, **16**, **19**, **20** | M1<br>A1 | 2 | For ranks as one group – starting at 11<br>All correct |
| **(b)** | $H_0$ Samples from identical populations<br>$H_1$ Samples not from identical populations 1% sig level | B1 | | $H_0$ $\eta_A = \eta_B = \eta_C = \eta_D$ or words<br>$H_1$ At least 2 medians differ |
| | Totals of ranks<br>$T_A = 33$ $T_B = 32½$ $T_C = 70½$ $T_C = 74$<br>$n_A = 5$ $n_B = 5$ $n_C = 5$ $n_D = 5$ | m1 | | Totals-any effort at any ranks total |
| | $\sum_{i=1}^{m} \frac{T_i^2}{n_i} = \frac{33^2}{5} + \frac{32\frac{1}{2}^2}{5} + \frac{70\frac{1}{2}^2}{5} + \frac{74^2}{5}$<br>$= 2518.3$ | m1<br>m1 | | Numerators correct<br>Denominators correct |
| | $H = \frac{12}{20 \times 21} \times 2518.3 - (3 \times 21)$<br>$= 8.95$ | m1 | | H formula $\frac{12}{20\times21}$ and –63<br>(8.6 – 9.2) |
| | Critical value from $\chi_3^2 = 11.345$<br>H < 11.345 | A1<br>B1 | | For cv 11.345 only |
| | Accept $H_0$ No reason to doubt that samples are from identical populations. No significant difference in average number of injuries for the four visiting teams involved. | E1 | 8 | Conclusion correct in context |
| **(c)** | A Type II error would be to conclude that $H_0$ is true, that is there is no difference between the average number of injuries for the four visiting teams involved when in fact $H_0$ is not true and the average numbers of injuries do differ. | B1<br>E1 | 2 | Correct Type II<br>In context |
| | **Total** | | **12** | |

| Q | Solution | Marks | Total | Comments |
|---|---|---|---|---|
| **5(a)** | Test A mean = 58.6 st dev = 19.2 or 20.3<br>Test B mean = 63.9 st dev = 16.0 or 17.0 | B1<br>B1B1 | 3 | B1for both means<br>B1,B1 for st dev<br>must be consistent, awrt |
| **(b)** | PMCC $r$ = 0.894 0r 0.893(3 sf ) (from calculator)<br>0.89 allow M1 M1 A0 (or B2)<br>0.9 allow B1 no method no ranks | B3 | 3 | or $r = \dfrac{36140 - \dfrac{527 \times 575}{9}}{57.552 \times 48.030}$ = 0.894 (3 sf)<br>M1( 36140) M1(formula),A1 |
| **(c)(i)** | $H_o$ Population median/mean/average score difference = 0<br>$H_1$ Population median/mean/average score difference $\neq 0$<br>2 tail test 5 % level | B1 | | or symbols $\mu$ $\eta$ equal or not<br>oe |
| | differences<br>1 2 3 4 5 6 7 8 9<br>4 –1 –17 –11 –15 –3 –2 10 –13 | M1 | | for differences |
| | ranks<br>4 1 9 6 8 3 2 5 7 | m1 | | all m dep diffs<br>for ranks- rank 1= smallest<br>disallow –17 rank 1 M0 |
| | $T_+$ = 4+ 5 = 9<br>$T_-$ = 1+ 9+ 6 + 3 + 2 + 8 + 7 = 36 | m1 | | for totals of any ranks |
| | test stat $T$ = 9<br>critical value = 6<br>test stat > 6 | A1<br>B1<br>m1 | | correct test stat<br>for cv (11,8,3 B0 M1 E0)<br>for comparison **lower** ts/cvft; must be seen unless **all** correct |
| | Accept $H_0$<br>There is no significant evidence of a difference in mean scores for the two tests | E1 | 8 | in context |
| **(ii)** | The differences are symmetrically distributed. | E1 | 1 | Must have differences |
| **(d)** | PMCC indicates results of tests show strong positive association – <u>consistent</u> results | E1 | | For PMCC result and <u>consistency/similarity</u> |
| | No sig difference in means so general similarity | E1 | | For no sig diff means and <u>similarity</u><br>(award for similarity once only) |
| | Higher st dev for test A indicates that this test may be more effective at discriminating between good/bad applicants | E1 | 3 | for mentioning st dev and <u>discrimination</u> |
| **(e)** | If separate groups took the 2 tests so there may be differences between the level of difficulty of the tests which would affect the results. | B1 | | concept of pairing removing effect of differences <u>in tests</u><br>disallow 'fair'<br>allow eliminates/reduces exp error<br>more likely to detect a difference if one exists |
| | Half the number of people needed | B1 | 2 | |
| | **Total** | | **20** | |

| Q | Solution | Marks | Total | Comments |
|---|---|---|---|---|
| **6** | $H_0$ Samples are taken from identical populations<br>$H_1$ Samples are not taken from identical populations<br>2 tails 5% | B1 | | $H_0$ $\eta_M = \eta_A$ or words ref<br>$H_1$ $\eta_M \neq \eta_A$ context<br>Disallow mean |
| | Separated times with Ranks | M1 | | Separated times effort (can be implied) |
| | **M** Times ranks / **A** Times ranks | M1 | | Ranks as one group (either way) |
| | 19.2 1 14 / 21.3 4 11<br>22.4 8 7 / 22.3 7 8<br>26.8 13 2 / 19.6 2 13<br>22.5 9 6 / 20.2 3 12<br>24.8 11 4 / 21.7 5½ 9½<br>24.6 10 5 / 21.7 5½ 9½<br>28.4 14 1 / 26.2 12 3 | A1 | | Ranks correct (5,6 or 9,10 OK) |
| | $T_M = 66$ 39 $T_A = 39$ 66<br>$n_M = 7$ $n_A = 7$ | m1 | | Ranks totalled ( any ranks)<br>m dep ranks |
| | $U_M = 66 - \frac{7\times8}{2} = 38$ | m1 | | Attempt to find $U$ dep ranks, totals |
| | $U_A = 39 - \frac{7\times8}{2} = 11$ | A1 | | Either $U$ correct |
| | $U = 11$<br>cv = 9 for $n$= 7, $m$ = 7 2 tail 5% | B1 | | cv correct cv = 9 only |
| | $U > 9$ | M1 | | correct comparison, ft on wrong ts – must see 11/lower $U$ oe upper tail unless all correct |
| | Accept $H_0$ | A1 | | only if cv = 9 and $U$ = 11 |
| | No significant evidence of any difference between average journey times when travelling for the morning shift or for the afternoon shifts | E1 | 11 | In context. Can ft conclusion |
| | **Total** | | **11** | |
| | **TOTAL** | | **75** | |