# A-LEVEL
# Statistics

## Statistics 3 – SS03
## Mark scheme

6380
June 2015

Version 1.0 Final

Mark schemes are prepared by the Lead Assessment Writer 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 associates 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 associate understands and applies it in the same correct way. As preparation for standardisation each associate 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, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Assessment Writer.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

Further copies of this Mark Scheme are available from aqa.org.uk

## 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.**

| Q1 | Solution | Marks | Total | Comments |
|---|---|---|---|---|
| **1(a)** | $r = 0.809$ from calculator | B3 | | sc 0.81 no workings B2<br>sc 0.8 no working B1 |
| | or $\sum xy = 158928$ B1<br>and $r = \dfrac{\frac{158928}{12} - \left(\frac{1495}{12} \times \frac{1271}{12}\right)}{\sqrt{\left(\frac{189473}{12} - \left(\frac{1495}{12}\right)^2\right) \times \left(\frac{134781}{12} - \left(\frac{1271}{12}\right)^2\right)}}$<br>oe | | | |
| | $= \dfrac{48.549}{16.383 \times 3.662} = 0.809$ M1 A1 | | | (0.799 – 0.815) |
| | | | **3** | |
| **1(b)** | $H_0$: $\rho = 0$<br>$H_1$: $\rho > 0$ 1 tail 1% | B1 | | Hypotheses oe |
| | test stat $r = 0.809$<br>critical value = 0.658 | | | Correct value for cv |
| | 0.809 > 0.658 so significant evidence exists to reject $H_0$ | B1<br>M1 dep cv | | Comparison 'ts'/cv [or Reject $H_0$] |
| | This suggests that there is a **positive correlation** between **height** and systolic **blood pressure** for healthy boys aged between 5 years and 10 years. | E1 | **4** | Conclusion correct in context<br>Dep ts and cv correct |
| **1(c)** | Conclusion can only refer to **healthy/boys no girls**, not all children | | **1** | |
| | | Total | **8** | |

**Mark Scheme**

| Q2 | Solution | Marks | Total | Comments |
|---|---|---|---|---|
| 2(a) | **Answer to Question**<br>**Yes** / **No**<br>**Year 13** **28** **(12)** 40<br>**Year 12** **7** **18** **25**<br>**(35)** **30** 65 | M1<br>M1<br>A1 | **3** | For 35 correctly place<br>For 12 correctly placed<br>All correct |
| 2(b) | $H_o$ Answer to question asked independent of year of study<br>$H_1$ Answer to question asked not independent of year of study | B1 | | oe $H_o$ No association/Independent<br>$H_1$ Association/Not Independent<br>B0 if nonsense |
| | 1 tail 1% | | | |
| | **Expected** / **Yes** / **No**<br>**Year 13** **21.54** **18.46**<br>**Year 12** **13.46** **11.54** | M1<br>A1 | | Method for expected freqs ( can be implied)<br>All correct – at least 1 dp |
| | ts = $\sum \frac{(\lvert O-E\rvert - 0.5)^2}{E}$<br>= $\frac{5.96^2}{21.54}+\frac{5.96^2}{18.46}+\frac{5.96^2}{13.46}+\frac{5.96^2}{11.54}$<br>= 1.65 + 1.92 + 2.64 + 3.08<br>= <u>9.29</u> | M1<br>A1 | | ts 'correct'<br>without Yates $\frac{6.46^2}{21.54}... = \frac{41.7}{21.54}..$ oe<br>(1.94+2.26+3.10+3.62 = 10.9*)<br>Yates used correctly<br>awfw 9.10 -9.50 |
| | cv df = 1 1% <u>cv = 6.635</u><br>ts > 6.635 Reject $H_o$ | B1 | | cv cao<br>p= <u>0.0023 < 0.01</u><br>**No Yates** used can gain M1A1 M1A0 B1E0 ts = 10.9<br>Note $\frac{(28-21.54)^2-0.5}{21.54}....$ = 10.79 oe M1A1M0A0B1E0 |
| | Significant evidence to suggest that the **answer** to the question, "Do you have part-time employment ?"is **not independent of ( is associated with )** the **year** of study. | E1 | **7** | Conclusion correct in context |

| | | | | |
|---|---|---|---|---|
| | | Total | **10** | |
| | • M1 A1 if scaled correctly x 0.851 | | | |

**Mark Scheme**

| Q3 | Solution | Marks | Total | Comments |
|---|---|---|---|---|
| **(a)** | Min $T$ = 1 + 2 + 3 + 4 + 5 + 6 = 21 | M1<br>A1 | **2** | M1 for addition effort 1 to 6 oe<br>sc 1 21-21 / 21 - $\frac{6\times 7}{2}$ = 0 |

| | | | | |
|---|---|---|---|---|
| **(b)** | $H_o$ The two populations have identical distributions<br>$H_1$ The two populations do not have identical distributions<br>2 tail 5% | B1 | | only |
| | $T_A = 46$ $\quad n_A = 7$ $\qquad$ $T_B = 74$ $\quad n_B = 8$ | | | |
| | $U_A = 46 - \frac{7\times 8}{2} = 18$ | M1 | | Attempt to find $U$ |
| | $U_B = 74 - \frac{8\times 9}{2} = 38$ | A1 | | Either $U$ correct |
| | Test stat $\underline{U = 18}$ | | | |
| | <u>cv = 11</u> for n= 7, m = 8 2 tail 5% | B1 | | cv correct ( or 45) |
| | **<u>U > 11</u>** | m1dep | | comparison consistent clear ( '18' with 11 or '38' with 45)<br>cv correct |
| | Accept $H_o$ | | | |
| | **No** significant evidence of a **difference** in **accuracy** for probes for the two **manufacturers, A and B**. | E1 | **6** | Correct conclusion in context (E0 if reference to mean or probes/manufacturers the same) |
| | | Total | **8** | |

**Mark Scheme**

| Q4 | Solution | Marks | Total | Comments |
|---|---|---|---|---|
| 4(a) | | | | |
| | Ranks: Bank A: Complaint 2 8, Satisfaction 8 2, Assets 1 9 | | | |
| | Bank B: Complaint 3 7, Satisfaction 7 3, Assets 2 8 | | | |
| | Bank C: Complaint 1 9, Satisfaction 9 1, Assets 3 7 | M1 | | Attempt to rank – any order |
| | Bank D: Complaint 5 5, Satisfaction 2½ 7½, Assets 4 6 | M1 | | Consistent ranking – all three |
| | Bank E: Complaint 6 4, Satisfaction 1 9, Assets 5 5 | M1 | | Ties correct<br>Can be implied by correct $r$ values |
| | Bank F: Complaint 9 1, Satisfaction 4 6, Assets 6 4 | | | |
| | Bank G: Complaint 4 6, Satisfaction 6 4, Assets 7 3 | | | |
| | Bank H: Complaint 7 3, Satisfaction 5 5, Assets 8 2 | | | |
| | Bank I: Complaint 8 2, Satisfaction 2½ 7½, Assets 9 1 | | | |
| (i) | $r_S = 0.767$ ( or 0.766) from calculator<br>or<br>$d$ = 1, 1, -2, 1, 1, 3, -3, -1, -1 | B3<br>or<br>M1 | | sc2 no method $r_S$ = 0.77 or 0.76<br>sc1 - 0.767<br>Differences and effort $\sum d^2$ |
| | $\sum d^2 =$ 28 | m1 | | Formula correct |
| | SRCC $r_s = 1 - \frac{6\times 28}{9\times 80} = 0.767$ | A1 | | awrt |
| (ii) | $r_S$ = - 0.544 (or -0.543) from calculator | B3 | | sc2 no method $r_S$ = - 0.54<br>sc1 + 0.544/3 |
| | or<br>$d$ = 7, 5, 6, -1.5, -4, -2, -1, -3, -6.5 | or<br>M1 | | Differences $\sum d^2$ |
| | $\sum d^2 =$ 184.5 | m1 | | Formula |
| | SRCC $r_s = 1 - \frac{6\times 184.5}{9\times 80}$ = - 0.537(5) or – 0.538 | A1 | **9** | awrt |

| | | | | |
|---|---|---|---|---|
| **(b)(i)** | $H_o$ Rank orders of upheld complaints and assets are independent.<br>$H_1$ Rank orders of upheld complaints and assets are not independent. | B1 | | Either pair of hypotheses correct or generic |
| | 2 tail 5% cv = 0.6833 $r_S = 0.767$<br>Reject $H_o$ Significant evidence at 5% level to suggest an **association/correlation** between rank orders of upheld **complaints and assets.** Banks with higher assets tend to have a higher level of upheld complaints. | B1<br>E1 | | cv correct ( condone +/- consistent)<br>Conclusion in context ts/cv consistent<br>Condone 'slight error' in part (a) |
| **(ii)** | $H_o$ Rank orders of customer satisfaction ratings and assets are independent.<br>$H_1$ Rank orders of customer satisfaction ratings and assets are not independent. | | | |
| | 2 tail 5% cv = - 0.6833<br>$r_S$= - 0.544 or -0.537/8<br>Accept $H_o$ **No** significant evidence at 5% level to suggest an **association** between rank orders of **customer satisfaction** ratings and **assets**. | B1<br>E1 | **5** | cv correct ( condone +/- consistent)<br>Conclusion in context ts/cv correct<br>Condone 'slight error' in part (a) |
| **(c)** | $H_o$ $\eta = 15$<br>$H_1$ $\eta < 15$ 1 tail test 10% level<br>Signs<br>- - - + + + - - +<br>test stat = 5 -/ 4+ | B1<br>M1<br>A1 | | Allow pop median<br>for signs<br>for test stat |
| | Bin (9, 0.5) model<br>P($\leq$ 4+) = 0.500 > 0.10<br>Or cr {0,1,2} or {7,8,9} inc probs seen | M1 | | for use of correct Bin model<br>( allow sc B1 for 0.746/0.254 seen )<br>and comparison ts and 10% |
| | Accept $H_o$ **No** significant evidence to suggest that **average customer satisfaction/ rating** is **less than 15**. | E1 | **5** | oe dep all correct<br>do not allow statement 'customer satisfaction rating is 15' |
| | | Total | **19** | |

**Mark Scheme**

| Q5 | Solution | Marks | Total | Comments |
|---|---|---|---|---|
| **(a)** | Ranks<br>**Terrific Teen** \| **Beetleman** \| **Hunk** \| **Warrior Crab**<br>4 \| 1 \| 6 \| **12**<br>7½ \| 2 \| **11** \| **16**<br>**9** \| 3 \| **14** \| **18**<br>**10** \| 5 \| **15** \| **19**<br>**13** \| 7½ \| **20** \| **21**<br>**17** \| | M1<br>m1<br>A1 | **3** | Start ranks at 9<br>At least 5 correct<br>All correct<br>sc1 start ranks at 8 and 5 consistent<br>sc2 start ranks at 8 all consistent<br>8, 9,12,16<br>10,13,14,19,21<br>11,15,17,18,20 |
| **5(b)** | $H_0$: Samples from identical populations<br>$H_1$: Samples not from identical populations<br>1% sig level | B1 | | oe Allow $\eta$ or pop median but need 'at least two differ'<br>[not 'at least one differs'] |
| | Totals<br>$T_{TTeen}$ =60½ $T_{Beetle}$= 18½ $T_{Hunk}$= 88 $T_{Crab}$= 86<br>$N_{TTeen}$ = 6 $n_{Beetle}$= 5 $n_{Hunk}$ = 6 $n_{Crab}$ = 5 | M1 | | Totals of <u>ranks</u><br>56½ **18½** 83 81 ft sc |
| | $\sum_{i=1}^{m} \frac{T_i^2}{n_i} = \frac{60.5^2}{6}+\frac{18.5^2}{5}+\frac{88^2}{6}+\frac{86^2}{5}$ = 3448.36 | m1 | | $\sum_{i=1}^{m} \frac{T_i^2}{n_i}$ m1 (sc1 3060.8 seen) |
| | $H = \frac{12}{22\times 23}\times 3448.36$ – (3 × 23) = 12.78 | M1<br>A1 | | H formula attempt **correct**<br>A1 awfw 12.4 – 13.8 |
| | Critical value from $\chi^2_3$ = <u>11.3(45)</u><br>$H > 11.345$ | B1 | | Cao 11.3 or better |
| | Significant evidence to <u>reject $H_0$</u> | A1dep | | Reject $H_0$ |
| | There is significant evidence of a difference between average scores **for at least 2** superhero **costumes**.<br>(can be implied by comment that children wearing **Beetleman** costumes are clearly **more exuberant than** those wearing **Warrior Crab** costumes. ) | E1dep<br>Rej <u>$H_0$</u> | | There is significant evidence of a difference between average scores for at **least 2 superhero costumes**.<br>(or ref to difference between Beetleman and Warrior crab.) |
| | **T Teen** \| **Beetle** \| **Hunk** \| **Crab**<br>rank score \| rank score \| rank score \| rank score<br>**Mean** 10 45.7 \| 3.7 66.2 \| 14.7 34.5 \| 17.2 29.6<br>**Med** 9.5 46 \| 3 65 \| 14.5 37 \| 18 30 | B1 | | Difference in exuberance and means/medians considered – ranks or raw scores **<u>seen</u>** considered |

| | | | | |
|---|---|---|---|---|
| | Children wearing **Beetleman** costumes clearly displayed **more exuberance** ( than those wearing Warrior Crab) | E1 | **10** | Mention Beetleman most exuberant (allow without backup) |
| | | Total | **13** | |

**Mark Scheme**

| Q6 | Solution | Marks | Total | Comments |
|---|---|---|---|---|

**6(a)**

$H_o$ $\eta$ or $\mu = 6.5$
$H_1$ $\eta$ or $\mu \neq 6.5$
2 tail test 1 % level

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **diff $x$-6.5** | - 2.3 | + 0.9 | - 1.5 | - 3.7 | + 0.8 | - 3 | - 2.6 |
| **rank** | 7 | 4 | 5 | 13 | 3 | 12 | 9 |
| | | | | | | | |
| **diff $x$-6.5** | + 0.7 | - 2.9 | - 4.3 | - 2.8 | 0 | - 1.7 | **- 0.6** |
| **rank** | 2 | 11 | 14 | 10 | . | 6 | **1** |
| | | | | | | | |
| **diff $x$-6.5** | - 2.4 | | | | | | |
| **rank** | 8 | | | | | | |

$T_+ = 4 + 3 + 2 = 9$
$T_- = 7 + 5 + 13 + \ldots. + 8 = 96$
test stat $T = 9$
critical value = 13
test stat 9 < cv 13

Reject $H_o$

There is significant evidence that the **median (average) time** for healthy adults taking the new drug **to** achieve persistent **sleep** when their regular bedtime is shifted earlier by five hours **differs ( is lower)** from 6.5 minutes.

B1 oe ref population medians/means

M1 Differences $x$ - 6.5 (disregard sign)

m1dep Ranks (smallest abs diff = rank 1)
Disallow assigning rank 1 to 0

m1dep Effort at total of any ranks
allow m1 here if zero included

A1 either total correct

B1 cao for cv

M1 Correct comparison 9,13 or 96,92

E1dep Correct conclusion in context

**8**

| Q6 | Solution | Marks | Total | Comments |
|---|---|---|---|---|
| **6(b) (i)** | So that any influence of the **order** of taking the different levels of the drug does **not affect** the outcome of the investigation. | 1 | | Condone decrease of 'demand characteristics' by volunteers |
| **6(b) (ii)** | $H_0$:Population mean $\mu$/median $\eta$(difference)=0<br>$H_1$:Population mean $\mu$/median $\eta$(difference)>0<br>1 tail test 5 % level | B1 | | difference 20mg – 50mg<br>or reverse $H_1$ and 50mg – 20mg<br>consistent with signs of differences |
| | Differences 20mg – 50mg<br>A B C D E F G H I J<br>–0.2 2.1 0.9 –0.6 1.7 –1 –0.3 1.9 2.2 0.4 | M1 | | For differences |
| | Ranks<br>1 9 5 4 7 6 2 8 10 3 | m1dep | | For ranks of any differences (smallest abs diff = rank1). |
| | $T_+$ = 9 + 5 + 7+ 8 + 10 + 3 = 42<br>$T_-$ = 1 +4+ 6 + 2 = 13<br>test stat $T$ = 13 | m1dep<br><br>A1 | | Effort at total of any ranks (dep ranks any effort)<br><br>Either total correct |
| | critical value = 11<br>test stat 13 > 11 | B1<br>M1 | | cv correct consistent<br>13 ,11 or 42,44 comparison |
| | Accept $H_o$<br>**No** significant evidence to suggest that the **average** number of **minutes/time** taken by healthy adults to achieve persistent sleep is **lower** when taking **50mg** of the new drug half an hour before bedtime than when taking 20mg of the new drug half an hour before bedtime. | E1 | **9** | Must be consistent with $H_1$<br>Disallow 'times taken are same' stated |
| | | Total | **17** | |