



General Certificate of Education (A-level)
June 2011

Statistics

SS06

(Specification 6380)

Statistics 6

Final

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 candidates' 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 candidates' 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) | | | | |
| (i) | Each child <u>was allocated</u> to take the amoxicillin or the placebo in a <u>random</u> manner, as if by chance alone. | E1 | | Need idea of <u>allocation to drug/treatment</u> Disallow 'same chance' unless ref to being allocated Allow 'allocated with no pattern' or 'no order' |
| (ii) | A harmless substance that looks like real medication but <u>does not contain any drug</u> . | E1 | | Allow 'has no effect', 'fake' treatment, 'looks same but doesn't do same thing' |
| (iii) | Neither the medical staff involved nor the children and their parents know whether the child is receiving the amoxicillin or the placebo. | E1 | 3 | Must make clear that neither group knows <u>which treatment</u> |
| (b) | | | | |
| (i) | To avoid parents/children <u>anticipating</u> a slow recovery simply because no drug treatment is offered. All children will appear to be taking the same medication if the placebo is used. | E1 | | (b) answers <u>do not need</u> to be in context of this trial Child/parent 'Not knowing' which drug so won't know what to expect. |
| (ii) | To <u>avoid expectations</u> by children and parents or by medical staff, of success/failure of the treatment <u>outcome</u> due to a knowledge of whether an active drug or a placebo was given, influencing the outcome. | E1 | 2 | Doctors and child/parent have no particular expectations due to knowledge of treatment Disallow 'Fair', 'reduces bias', 'reduces experimental error' |
| Total | | | 5 | |

| Q | Solution | Marks | Total | Comments | | | | | | | | | | | | |
|--|---|--------|---|--|-------|-------|---|------|--------|--------|------|-------|-------|--|--|--|
| 2(a) | H ₀ pop mean diff $\mu_d = 0$ H ₁ pop mean diff $\mu_d < 0$ 1 tail 5% | | | Condone μ or population mean/average Condone explained in words ref to average price/difference or pop average allow $\mu_d > 0$ if consistent H ₁ must be consistent with their differences | | | | | | | | | | | | |
| | $d = \text{Yorks} - \text{Surrey}$ | B1 | | | | | | | | | | | | | | |
| | <table border="1"><tr><td></td><td>A</td><td>B</td><td>C</td><td>D</td><td>E</td></tr><tr><td>d</td><td>-10.09</td><td>-1.63</td><td>1.35</td><td>-1.13</td><td>-2.67</td></tr></table> | | A | B | C | D | E | d | -10.09 | -1.63 | 1.35 | -1.13 | -2.67 | | | |
| | | A | B | C | D | E | | | | | | | | | | |
| | d | -10.09 | -1.63 | 1.35 | -1.13 | -2.67 | | | | | | | | | | |
| | <table border="1"><tr><td></td><td>F</td><td>G</td><td>H</td><td>I</td></tr><tr><td>d</td><td>3.75</td><td>-8.23</td><td>-11.43</td><td>1.23</td></tr></table> | | F | G | H | I | d | 3.75 | -8.23 | -11.43 | 1.23 | | | | | |
| | | F | G | H | I | | | | | | | | | | | |
| | d | 3.75 | -8.23 | -11.43 | 1.23 | | | | | | | | | | | |
| | $\bar{d} = -3.21 \quad s = 5.43 \quad n = 9$ | M1 | | Differences – either way | | | | | | | | | | | | |
| | $t = \frac{-3.21 - 0}{5.43 / \sqrt{9}} = -1.77$ | m1 | | attempt to find \bar{d} , s | | | | | | | | | | | | |
| | M1 | | Use of $\frac{s}{\sqrt{9}}$ ft | | | | | | | | | | | | | |
| | m1 | | Method for t ft | | | | | | | | | | | | | |
| | A1 | | (\pm) 1.77 (1.7 – 1.8) (\pm) 1.77 no method 5 marks | | | | | | | | | | | | | |
| df = 8 cv = 1.86 1.77 < 1.86 oe | B1 B1 | | df for <u>correct cv</u> or p = 0.115 | | | | | | | | | | | | | |
| Accept H ₀ $+/+$ and $-/-$ comp only No significant evidence to suggest that mean prices are lower in Yorkshire. | A1 | 9 | correct <u>conclusion in context</u> need ts/cv both correct | | | | | | | | | | | | | |
| (b)(i) | (Differences between average prices for Yorkshire and Surrey are) <u>normally distributed</u> . | E1 | 1 | Allow <u>random and normally</u> dist | | | | | | | | | | | | |
| (ii) | <u>Sign test</u> . Not normal might well mean differences are not symmetrically distributed so sign test safer as <u>needs no assumption regarding distribution</u> of sample data. | B1 | | Sign test | | | | | | | | | | | | |
| | | E1 | | or ‘diffs/data do not need to be normally distributed’ | | | | | | | | | | | | |
| | OR | | | | | | | | | | | | | | | |
| | Wilcoxon Signed-Rank test No clear evidence differences are not symmetrically distributed so can <u>assume symmetry</u> and W S-R preferred to sign test as rank orders of differences taken into account. | (B1) | | Wilcoxon Signed-Rank | | | | | | | | | | | | |
| | | (E1) | 2 | Allow’ W S-R does not require normally distributed data’ <u>Disallow W S-R more powerful</u> unless being compared to sign test | | | | | | | | | | | | |
| | Total | | 12 | | | | | | | | | | | | | |

| Q | Solution | Marks | Total | Comments | | | | | | | | | | | | | | | | |
|------|---|----------------|-------|--|---|---------|--------|---|--------|-------|---------|----|-------|-------|---------|----|--|----|--|------------------------|
| 3(a) | $T_A = 2857 \quad T_B = 2490 \quad T_C = 3190$ $n_A = 6 \quad n_B = 5 \quad n_C = 7$ $T = 8537$ $\sum \sum x_{ij}^2 = 4\,067\,243 \quad N = 18$ $\sum \frac{T_i^2}{n_i} = \frac{2857^2}{6} + \frac{2490^2}{5} + \frac{3190^2}{7}$ $= 4054156.7$ $SS_{\text{Methods}} = 4054156.7 - \frac{8537^2}{18}$ $= 5247.3$ $SS_{\text{Total}} = 4\,067\,243 - \frac{8537^2}{18}$ $= 18333.6$ | | | | | | | | | | | | | | | | | | | |
| | <table border="1"><thead><tr><th></th><th>SS</th><th>df</th><th>ms</th></tr></thead><tbody><tr><td>Methods</td><td>5247.3</td><td>2</td><td>2623.6</td></tr><tr><td>Error</td><td>13086.3</td><td>15</td><td>872.4</td></tr><tr><td>Total</td><td>18333.6</td><td>17</td><td></td></tr></tbody></table> | | SS | df | ms | Methods | 5247.3 | 2 | 2623.6 | Error | 13086.3 | 15 | 872.4 | Total | 18333.6 | 17 | | m1 | | Error SS ft (not –ve) |
| | | SS | df | ms | | | | | | | | | | | | | | | | |
| | Methods | 5247.3 | 2 | 2623.6 | | | | | | | | | | | | | | | | |
| | Error | 13086.3 | 15 | 872.4 | | | | | | | | | | | | | | | | |
| | Total | 18333.6 | 17 | | | | | | | | | | | | | | | | | |
| | | | m1 | | Method for MS – both correct ft incorrect df | | | | | | | | | | | | | | | |
| | $F = \frac{2623.6}{872.4} = 3.01$ | m1 A1 | | | Method for F ft 2.8 – 3.2 3.01/in range with <u>no</u> <u>method</u> seen allow 6 marks (or p = 0.080) | | | | | | | | | | | | | | | |
| | $H_0 \mu_A = \mu_B = \mu_C$ H_1 at least 2 of the means differ | | | | | | | | | | | | | | | | | | | |
| | $F_{15}^2 = 3.682 > 3.01$ <u>Accept H_0. There is no significant evidence of a difference in(mean) reading achievement scores for the 3 methods. Allow no difference in teaching methods.</u> | B1 B1 A1 | 9 | | df correct cv correct correct ts/cv and conclusion <u>in context</u> | | | | | | | | | | | | | | | |
| (b) | Assumptions: Reading scores are <u>normally distributed</u> for each method The normal populations of reading scores have a <u>common variance</u> | E1 E1 | 2 | Normal mentioned Explanations <u>in some sort of context (scores appears) in one</u> of the comments here Disallow ‘random’, ‘no interaction’ | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | |
| | Total | | 11 | | | | | | | | | | | | | | | | | |

| Q | Solution | Marks | Total | Comments |
|------|---|---|-------|--|
| 4(a) | <p>Total with misregistration = $9 + 12 + \dots = 81$</p> <p>Total wafers inspected = 480</p> <p>Estimate for $p = \frac{81}{480}$ (0.16875)</p> <p>Warning 95% control limits</p> $\frac{81}{480} \pm 1.96 \times \sqrt{\frac{81/480 \times 399/480}{60}}$ <p>= (0.074 , 0.264)</p> <p>Action 99.8% control limits</p> $\frac{81}{480} \pm 3.09 \times \sqrt{\frac{81/480 \times 399/480}{60}}$ <p>= (0.019 , 0.318)</p> | <p>M1</p> <p>m1</p> <p>A1</p> <p>B1</p> <p>M1</p> <p>m1</p> <p>A1</p> <p>A1</p> | | <p><u>Total</u> misregistered attempt</p> <p><u>ft total</u> misregistered ÷ 480</p> <p>0.168/0.169 awrt</p> <p>Mark if seen in either limits</p> <p>Use of <u>1.96 and 3.09</u></p> <p>Use of $\frac{p(1-p)}{n}$ for</p> <p>n = 60 or 8 or 480</p> <p>Correct expression</p> <p>0.073/0.075 0.263/0.265</p> <p>awrt to 2 sf</p> <p>0.018/0.020 0.317/0.319</p> <p>awrt to 2 sf</p> |
| (b) | <p>(i) $p = \frac{20}{60}$ (= 0.333)</p> <p>Stop process immediately as p above upper action limit</p> <p>(ii) $p = \frac{16}{60}$ (= 0.267)</p> <p>Take another sample immediately as p between upper warning and action limits</p> <p>(iii) $p = \frac{3}{60}$ (= 0.05)</p> <p>Below lower warning limit. <u>Investigate to find out why misregistration proportions have improved</u> so much</p> | <p>M1</p> <p>E1</p> <p>E1</p> <p>E1</p> <p>E1</p> <p>E1</p> | | <p><u>finding p correctly</u> in any part</p> <p><u>E1 no ft</u> unless small arithmetic slip and all methods OK</p> <p>For ‘below warning’ or ‘take another sample’</p> <p>For investigation of improvement</p> |
| | | | 13 | |

| Q | Solution | | | | Marks | Total | Comments |
|------|--|---------------|---------------|---------------|----------------|-------|--|
| 5(a) | p | 0.01 | 0.05 | 0.10 | | | |
| | P(acc) R | 0.7397 | 0.2146 | 0.0424 | | | |
| | P(acc) S | 0.9639 | 0.5535 | 0.1837 | | | |
| | P(acc) T | 0.9691 | 0.5119 | 0.1259 | | | |
| | Plan R P(0) $n = 30$ | | | | M1 | | method seen/any one prob correct |
| | Plan S P(≤ 1) $n = 30$ | | | | M1 A1 | | 1 correct 2 correct M1 can be gained in Plan R or Plan S solutions |
| | Plan T $p = 0.05$ $= 0.2774 + 0.3650 \times 0.6424$ | | | | B1 | | correct prob seen (.6424 or .2774) |
| | | | | | M1 | | double sample attempt |
| | | | | | m1 | | $n = 25$ throughout |
| | $= 0.512 \text{ (} 0.50 - 0.52 \text{)}$ | | | | A1 | 7 | |
| (b) | Plot: any attempt to plot one correct all correct | | | | M1 A1 A1 | 3 | Any one thro (0,1) One All correct by eye T ‘in middle’ |
| (c) | (i) 0.30 | | | | B1 | 1 | (0.28 – 0.32) |
| | (ii) 0.77 | | | | B1 | 1 | (0.74 - 0.79) |
| (d) | Plan S P(rej) = $\underline{1 - 0.9639} = \underline{0.0361}$ | | | | M1 | | Prob rejection |
| | P(0,1) for $n = 7$ and $p = 0.0361$ | | | | m1 | | Binomial used correctly $n = 7$ |
| | Prob(more than 1) = $1 - P(0,1)$ $= 1 - 0.9758$ $= 0.0242$ | | | | m1 | | |
| | | | | | A1 | | (0.0240 – 0.0245) |
| | | | | | | 4 | |
| | Total | | | | | 16 | |

| Q | Solution | Marks | Total | Comments | | | | | | | | | | | | | | | | | | | | |
|----------|--|----------|-------|--|----|-------------|---------|---|--------|-------|--------|---|--------|-------|-------|---|------|-------|---------|----|--|----------|--|---|
| 6 (a)(i) | $T_{Tv}=2322.1$ $T_{News}=2461.2$ $T_{Rad}=2338.5$ $n_{Tv} = 4$ $n_{News} = 4$ $n_{Rad} = 4$ $T_{Con}=1692.6$ $T_{Qual}=1970.4$ $T_{Cost}=1829.6$ $n_{Conv} = 3$ $n_{Qual} = 3$ $n_{Cost} = 3$ $T_{Health}=1629.2$ $n_{Health} = 3$ $T= 7121.8$ $\sum \sum x_{ij}^2 = 4253083.0$ N=12 Total SS $4253083.0 - \frac{7121.8^2}{12} = \underline{26413.4}$ Advertising approach SS C $\frac{1692.6^2}{3} + \frac{1970.4^2}{3} + \frac{1829.6^2}{3} + \frac{1629.2^2}{3}$ $- \frac{7121.8^2}{12} = \underline{23030.3}$ Media SS R $\frac{2322.1^2}{4} + \frac{2461.2^2}{4} + \frac{2338.5^2}{4} - \frac{7121.8^2}{12}$ $= \underline{2889.4}$ | | | | | | | | | | | | | | | | | | | | | | | |
| | | M1 | | Total SS method – must have correct given values | | | | | | | | | | | | | | | | | | | | |
| | | M1 | | Adv approach SS method ft | | | | | | | | | | | | | | | | | | | | |
| | | M1 | | Media SS method ft | | | | | | | | | | | | | | | | | | | | |
| | <table border="1"><tr><td></td><td>SS</td><td>df</td><td>ms</td></tr><tr><td>Advert Appr</td><td>23030.3</td><td>3</td><td>7676.8</td></tr><tr><td>Media</td><td>2889.4</td><td>2</td><td>1444.7</td></tr><tr><td>Error</td><td>493.7</td><td>6</td><td>82.3</td></tr><tr><td>Total</td><td>26413.4</td><td>11</td><td></td></tr></table> | | SS | df | ms | Advert Appr | 23030.3 | 3 | 7676.8 | Media | 2889.4 | 2 | 1444.7 | Error | 493.7 | 6 | 82.3 | Total | 26413.4 | 11 | | M1 B1 | | Error SS ft (not –ve) Error df= 6 correct |
| | | SS | df | ms | | | | | | | | | | | | | | | | | | | | |
| | Advert Appr | 23030.3 | 3 | 7676.8 | | | | | | | | | | | | | | | | | | | | |
| | Media | 2889.4 | 2 | 1444.7 | | | | | | | | | | | | | | | | | | | | |
| | Error | 493.7 | 6 | 82.3 | | | | | | | | | | | | | | | | | | | | |
| | Total | 26413.4 | 11 | | | | | | | | | | | | | | | | | | | | | |
| | $H_0 \mu_{con} = \mu_{qual} = \mu_{cost} = \mu_{health}$ H_1 at least 2 of the means differ | M1 m1 | | Method for Ad/Med MS ft Method (dep prev M's) for F (either) | | | | | | | | | | | | | | | | | | | | |
| | $F = \frac{7676.8}{82.3} = \underline{93.3(91 -95)}$ $F \frac{3}{6} = \underline{9.78}$ $93.3 > 9.78$ Reject H_0 | A1 B1 | | Adv approach F correct cv = 9.78 | | | | | | | | | | | | | | | | | | | | |
| | $H_0 \mu_{Tv} = \mu_{Newspaper} = \mu_{Radio}$ H_1 at least 2 of the means differ | | | sc df muddled Allow B1, B1 for 9.78, 10.925 in any part | | | | | | | | | | | | | | | | | | | | |
| | $F = \frac{1444.7}{82.3} = \underline{17.6(16.5 - 18.5)}$ $F \frac{2}{6} = \underline{10.925}$ $17.6 > 10.925$ Reject H_0 | A1 B1 | | Media F correct cv = 10.925 | | | | | | | | | | | | | | | | | | | | |
| | There is significant evidence of a difference in(mean) sales for the 4 adv approaches and also for the 3 media types used. | A1 E1 | | Correct conclusions (both reject) ts/cv correct In context ref to sales and advert & media | | | | | | | | | | | | | | | | | | | | |
| | | 13 | | | | | | | | | | | | | | | | | | | | | | |

| | | | | | |
|---------------|--------|--|----|-----------|--|
| 6(a) cont. | (ii) | <p>part (i) indicates a significant difference between at least two advertising approaches.</p> <p><u>Means</u> are $\bar{X}_{Con}=564.2$ $\bar{X}_{Qual}=656.8$ $\bar{X}_{Cost}=609.9$ and $\bar{X}_{Health}=543.1$</p> <p><u>Quality clearly has the highest</u> mean sales. Chose Quality approach</p> | M1 | | Use of means or totals for comparisons |
| | | | A1 | 2 | Quality chosen |
| | (b)(i) | There is <u>no interaction</u> between the two factors. | E1 | 1 | For no interaction |
| | (ii) | There is no particular reason why one advertising approach should <u>be more or less suited to one media type</u> rather than any other. | E1 | | General idea of assumption that each advertising approach has the same effect no matter whast media type is used |
| | | | E1 | 2 | Explained precisely |
| | | Total | | 18 | |
| | | TOTAL | | 75 | |