A-LEVEL
STATISTICS

Statistics 6 – SS06
Mark scheme

6380
June 2014

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.

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<table>
<tr><th>Q</th><th>Solution</th><th>Marks</th><th>Total</th><th>Comments</th></tr>
<tr><td>1(a)</td><td>16 birds/feathers can be regarded as a random sample.
Differences in yellowness index can be assumed to be normally distributed.</td><td>E1
E1</td><td>2</td><td>At least one in context for E2
sc B1 for both reasons, no context</td></tr>
<tr><td>1(b)</td><td>H_o pop mean diff $\mu_d = 0$
H₁ pop mean diff $\mu_d > 0$
1 tail 1%</td><td>B1</td><td></td><td>Consistent with differences
Odd – Typical H₁ $\mu_d < 0$</td></tr>
<tr><td></td><td><i>d</i> = Typical - Odd
<table>
<tr><td></td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td></tr>
<tr><td><i>d</i></td><td>+.069</td><td>-.028</td><td>+.109</td><td>-.041</td><td>-.018</td><td>+.014</td><td>+.249</td><td>+.08</td></tr>
<tr><td></td><td>9</td><td>10</td><td>11</td><td>12</td><td>13</td><td>14</td><td>15</td><td>16</td></tr>
<tr><td><i>d</i></td><td>+.032</td><td>+.189</td><td>+.119</td><td>+.37</td><td>+.386</td><td>+.241</td><td>+.183</td><td>+.238</td></tr>
</table></td><td>M1
A1</td><td></td><td>Differences ignore sign
At least 3 correct</td></tr>
<tr><td></td><td>$\bar{d} = 0.137$ $s = 0.135$ $n = 16$</td><td>m1dep</td><td></td><td>attempt to find $\bar{d}$, s</td></tr>
<tr><td></td><td>$t = \frac{0.137 - 0}{0.135/\sqrt{16}}$ = 4.05 to 4.07</td><td>M1
m1ft</td><td></td><td>Use of $\frac{s}{\sqrt{16}}$ ft</td></tr>
<tr><td></td><td></td><td>A1</td><td></td><td>(±) 4.06</td></tr>
<tr><td></td><td>df = 15
|cv|=2.602</td><td>B1</td><td></td><td>cao cv
p=0.00051 comp 1%</td></tr>
<tr><td></td><td>Reject H_o
Significant evidence to suggest that odd tail feathers are less yellow than typical feathers.</td><td>A1dep
E1dep</td><td></td><td>dep correct ts and cv(both + or both -)
In context dep A1</td></tr>
<tr><td></td><td></td><td></td><td>10</td><td></td></tr>
</table>

<table>
<tr><th>Q</th><th>Solution</th><th>Marks</th><th>Total</th><th>Comments</th></tr>
<tr><td>2(a)
(i)</td><td><table><tr><td>Mean</td><td>19.2</td><td>19.4</td><td>19.6</td><td>19.8</td><td>20.0</td><td>20.2</td><td>20.4</td></tr><tr><td>Prob</td><td>.068</td><td>.228</td><td>.5</td><td>.772</td><td>.932</td><td>.987</td><td>.999</td></tr></table></td><td>B1m1
A1</td><td>3</td><td>B1 for 0.5
m1 for $z = \frac{19.6-\mu}{0.6/\sqrt{5}}$ or 1 prob correct
3 others correct</td></tr>
<tr><td>(ii)</td><td>On graph</td><td>M1 A1</td><td>2</td><td>M1 effort and at least 3 points joined
A1 all correct</td></tr>
<tr><td>(iii)</td><td>Quite high chance of acceptance at mean 19.8/20 kg when some bags may well have contents below 20kg
Low chance of batch acceptance at low mean and high chance at high mean so plan seems OK</td><td>E1</td><td>1</td><td>Relevant comment</td></tr>
<tr><td>(b)
(i)</td><td>$\frac{w-19.4}{0.6/\sqrt{4}} \geq 1.645$</td><td>B1
M1</td><td></td><td>For 1.645
For z formula 19.4 and $\frac{0.6}{\sqrt{4}}$ seen
Condone 19.4 - w</td></tr>
<tr><td></td><td>$w \geq 19.4 + 1.645 \times 0.6/\sqrt{4}$</td><td>m1</td><td></td><td>Rearrangement of inequality</td></tr>
<tr><td></td><td>$w \geq 19.893$
Weight to be exceeded is 19.9 kg</td><td>A1</td><td>4</td><td>19.89 or 19.9 only</td></tr>
<tr><td>(ii)</td><td>$\frac{19.6-20}{0.6/\sqrt{n}} \leq -1.75$
$-0.4 \leq -1.75 \times 0.6/\sqrt{n}$</td><td>B1
M1</td><td></td><td>For – 1.75
For z formula (19.6 -20) in numerator</td></tr>
<tr><td></td><td>$0.4\sqrt{n} \geq 1.05$
$n \geq 6.89$</td><td>m1</td><td></td><td>Rearrangement of inequality or equality</td></tr>
<tr><td></td><td>Minimum number is 7</td><td>A1</td><td>4</td><td>$n = 7$ only
Condone confused signs</td></tr>
<tr><td></td><td>sc Trial and improvement

M1 probs seen any 2 for M1A1 if correct
19.7 .158
19.8 .091
19.9 .048
20.0 .023
If answer correct then B4</td><td></td><td></td><td></td></tr>
</table>

<table>
<tr><th>Q</th><th>Solution</th><th>Marks</th><th>Total</th><th>Comments</th></tr>
<tr><td>3(a)</td><td>$\hat{p} = \frac{4+7+5+\ldots\ldots\ldots+7}{80+110+90+\ldots..+95} = 0.06$</td><td>M1A1</td><td></td><td>M1 Sum of non-conf components / n
A1 cao</td></tr>
<tr><td></td><td>$\hat{n} = \frac{80+110+90+\ldots\ldots+95}{10} = 100$</td><td>A1</td><td>3</td><td>(M1) Sum of numbers inspected /10
A1 cao</td></tr>
<tr><td>3(b)</td><td>Warning Limits
$0.06 \pm 1.96 \times \sqrt{\frac{0.06 \times 0.94}{100}}$</td><td>M1ft</td><td></td><td>+ only necessary.
Need 1.96 and any effort</td></tr>
<tr><td></td><td>(0.0134/5 , 0.106/7)</td><td>A1</td><td></td><td>For upper</td></tr>
<tr><td></td><td>Action Limits
$0.06 \pm 3.09 \times \sqrt{\frac{0.06 \times 0.94}{100}}$</td><td>M1ft</td><td></td><td>+ only necessary
Need 3.09 and any effort</td></tr>
<tr><td></td><td>(-0.0133/4 or 0 , 0.133)</td><td>A1</td><td>4</td><td>For upper</td></tr>
<tr><td>3(c)</td><td>Proportion for each sample
$\frac{4}{80}, \frac{7}{110}, \ldots\ldots\ldots \frac{7}{95}$</td><td>M1ftA1</td><td></td><td>Effort at finding proportions as decimals</td></tr>
<tr><td></td><td><table>
<tr><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th></tr>
<tr><td>0.05</td><td>0.064</td><td>0.056</td><td>0.093</td><td>0.054</td></tr>
<tr><td>6</td><td>7</td><td>8</td><td>9</td><td>10</td></tr>
<tr><td>0.05</td><td>0.057</td><td>0.04</td><td>0.076</td><td>0.074</td></tr>
</table></td><td>A1</td><td></td><td>At least 4 correct</td></tr>
<tr><td></td><td>All proportions lie below upper warning limit (0.106/7) therefore production is fine</td><td>M1
E1</td><td>4</td><td>All values below 0.106/7 correct
Production fine
sc B1 Clear comparison ‘their’ UWL and ‘their’ proportions.</td></tr>
<tr><td>(d)(i)</td><td>$\frac{3}{85} = 0.035$ Proportion below upper warning limit so OK. No action needed</td><td>M1
E1dep</td><td></td><td>M1 for finding proportion</td></tr>
<tr><td>(ii)</td><td>$\frac{12}{85} = 0.141$ Proportion above upper action limit so stop production immediately.</td><td>M1
E1dep</td><td>4</td><td>M1 for finding proportion</td></tr>
</table>

<table>
<tr><th>Q</th><th>Solution</th><th>Marks</th><th>Total</th><th>Comments</th></tr>
<tr><td>4a(i)</td><td>
<table>
<tr><th colspan="2">Treatment</th></tr>
<tr><th>Placebo</th><th>New vaccine</th></tr>
<tr><td>10</td><td>10</td></tr>
</table>
Explanation: volunteers allocated a number. Numbers randomly selected and allocated to placebo or new vaccine.</td><td>E1</td><td></td><td>Does not have to be 10/10 but 2 allocated numbers of volunteers must sum to 20
Split randomly and each allocated to a treatment + table</td></tr>
<tr><td>(ii)</td><td>
<table>
<tr><th></th><th></th><th colspan="2">Treatment</th></tr>
<tr><th></th><th></th><th>Placebo</th><th>New vaccine</th></tr>
<tr><th>Sex</th><th>Male</th><td>5</td><td>5</td></tr>
<tr><th></th><th>Female</th><td>5</td><td>5</td></tr>
</table>
Explanation: volunteers allocated to subgroups or blocks by sex/age and then randomly assigned to either placebo or new vaccine.</td><td>B1
E1</td><td></td><td>Blocking used – age/sex
Blocking explained + table</td></tr>
<tr><td>(iii)</td><td>
<table>
<tr><th></th><th></th><th colspan="2">Treatment</th></tr>
<tr><th></th><th></th><th>Placebo</th><th>New vaccine</th></tr>
<tr><th>Pair</th><td>1</td><td>1</td><td>1</td></tr>
<tr><th></th><td>2</td><td>1</td><td>1</td></tr>
<tr><th></th><td>…..</td><td></td><td></td></tr>
<tr><th></th><td>10</td><td>1</td><td>1</td></tr>
</table>
Volunteers are placed into pairs based on sex and age. Within each pair, volunteers are randomly allocated to receive the placebo or the new vaccine.</td><td>B1
E1
E1</td><td>6</td><td>Pairing for age and/or sex idea
Explanation of pairing
Table and explanation with consideration of sex and age.</td></tr>
<tr><td>b(i)</td><td>No bias in allocation of adults to placebo or vaccine treatment.
or Simple to set up.</td><td>E1</td><td></td><td>Removal of any bias in allocation or simple to organise</td></tr>
<tr><td>(ii)</td><td>Use of a blocking factor (for sex or age) removes effect of this factor on experimental outcome so that observed differences can be attributed only to treatment (placebo or vaccine) used.</td><td>E1</td><td></td><td>Removal of effect of one blocking factor</td></tr>
<tr><td>(iii)</td><td>Experimental error reduced as the adults can be paired as closely as possible so that any difference in outcome can be attributed only to treatment (placebo or vaccine) used.</td><td>E1</td><td>3</td><td>Reduction in expt error as differences between outcome for paired adults should be due to treatment only.
eg could consider age, sex health and whether a smoker or not or whether an asthma sufferer or not.</td></tr>
<tr><td>(c)</td><td>Matched pairs as more likely to detect whether vaccine is effective or not since other factors controlled by pairing.</td><td>B1E1</td><td>2</td><td>B1 matched pairs
E1 detect difference better</td></tr>
</table>

<table>
<tr><th>Q</th><th>Solution</th><th>Marks</th><th>Total</th><th>Comments</th></tr>
<tr><td>5(a)(i)</td><td>A B C D E F G
$T_A=13$ $T_B=33$ $T_C=45$ $T_D=16$ $T_E=18$ $T_F=21$ $T_G=17$
$n_A=3$ $n_B=3$ ………………………… $n_G=3$

T = 163
$\sum\sum x_{ij}^2 = 1705$ N = 21
Making
$$\sum\frac{T_j^2}{n_j}=\frac{73^2}{7}+\frac{54^2}{7}+\frac{36^2}{7} = 1363$$
Tea Brands
$$\sum\frac{T_i^2}{n_i}=\frac{13^2}{3}+\frac{33^2}{3}+\text{.........}+\frac{17^2}{3} =1531$$</td><td></td><td></td><td></td></tr>
<tr><td></td><td>$SS_{\text{makings}} = 1363 - \frac{163^2}{21}$
$= 97.81$</td><td>M1ft</td><td></td><td>SS for makings attempt</td></tr>
<tr><td></td><td>$SS_{\text{teas}} = 1531 - \frac{163^2}{21}$
$= 265.81$</td><td>M1ft</td><td></td><td>SS for teas attempt</td></tr>
<tr><td></td><td>$SS_{\text{Total}} = 1705 - \frac{163^2}{21}$
$= 439.81$</td><td>M1ft</td><td></td><td>SS for total attempt</td></tr>
<tr><td></td><td>
<table>
<tr><th></th><th>SS</th><th>df</th><th>ms</th></tr>
<tr><td>Makings</td><td>97.81</td><td>2</td><td>48.91</td></tr>
<tr><td>Tea Brands</td><td>265.81</td><td>6</td><td>44.30</td></tr>
<tr><td>Error</td><td>76.19</td><td>12</td><td>6.35</td></tr>
<tr><td>Total</td><td>439.81</td><td>20</td><td></td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
</table>
</td><td>M1ft
m1ft</td><td></td><td>Error SS ft (not –ve)
Method for ms (not –ve)
Condone only one correct or clear method seen ft</td></tr>
<tr><td></td><td>H_O $\mu_{first}=\mu_{second}=\mu_{Third}$
H_1 at least 2 of the means differ
Ts $=\frac{48.91}{6.35}=7.70$ $F^{2}_{12}=3.885 < 7.70$
Reject H_O.</td><td>B1
m1ft
B1
A1dep</td><td></td><td>Correct hypotheses seen once
Method for F for makings
cv correct 3.885
or p = 0.007</td></tr>
<tr><td></td><td>H_O $\mu_A=\mu_B=\text{........}=\mu_G$
H_1 at least 2 of the means differ
$=\frac{44.30}{6.35}=6.98$ $F^{6}_{12}=2.996 < 6.98$
Reject H_O.</td><td>m1ft
B1
(A1)</td><td></td><td>A1 dep ts/cv or p correct
Method for F for teas
cv correct 2.996
or p = 0.0022</td></tr>
</table>

<table>
<tr><td></td><td>There is a significant difference between at least two of the making orders and between at least two of the brands</td><td>E1dep</td><td>12</td><td>A1 for Reject for both
E1 In context for both dep A1
Might see in earlier conclusions</td></tr>
<tr><td>(ii)</td><td>First making is significantly preferred to the third making.

Don’t use a tea bag more than twice, preferably only once

Brand C seems to be the favourite tea brand and Brand A the least favourite</td><td>E1
or
E1
or
E1</td><td>2</td><td>For any two relevant comments</td></tr>
<tr><td>(b)(i)</td><td>There is no interaction [between tea brand and making order.]

One brand is not better/worse at particular making.</td><td>B1

E1</td><td></td><td></td></tr>
<tr><td>(ii)</td><td>The population of ratings is normal and the ratings have a common variance</td><td>B1
E1</td><td>4</td><td>Normal and common variance
Reference to context/ratings somewhere</td></tr>
<tr><td>(c)</td><td>H_o pop mean/median diff $= 0$
H_1 pop mean/median diff $\neq 0$</td><td></td><td></td><td>or μ_d, η_d used</td></tr>
<tr><td></td><td>Ranks
<table>
<tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>10</td></tr>
<tr><td>9
1
-</td><td>2
8
+</td><td>5
5
-</td><td>.</td><td>1
9
-</td><td>3½
6½
-</td><td>7
3
-</td><td>6
4
-</td><td>8
2
-</td><td>3½
6½
+</td></tr>
</table></td><td>M1</td><td></td><td>ranks – any effort</td></tr>
<tr><td></td><td>$T_- = 9 + 5 + 1 + 3½ + 7 + 6 + 8 = 39½$
$T_+ = 2 + 3½ = 5½$</td><td>m1
A1</td><td></td><td>totals of ranks +/-
correct</td></tr>
<tr><td></td><td>ts $T_+ = 5½$ cv = 6 $T_+ < 6$ Reject H_0
There is a significant difference the brands – C preferred</td><td>B1
E1dep</td><td>5</td><td>cv correct and correct comparison with lower ts
in context ts and cv correct and hypotheses effort</td></tr>
</table>