A-LEVEL

Statistics

SS06

Final Mark Scheme

6380

June 2017

Version/Stage: v1.0

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.

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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.

<table>
<tr><th>Q1</th><th>Solution</th><th>Marks</th><th>Total</th><th>Comments</th></tr>
<tr><td>(a)</td><td>H_o pop mean diff $\mu_d = 0$
H_1 pop mean diff $\mu_d > 0$ 1 tail 1%
d = Robusta - Arabica
<table><tr><td></td><td>A</td><td>B</td><td>C</td><td>D</td><td>E</td></tr><tr><td>d</td><td>133</td><td>104</td><td>-87</td><td>-86</td><td>142</td></tr><tr><td></td><td>F</td><td>G</td><td>H</td><td>I</td><td>J</td></tr><tr><td>d</td><td>101</td><td>185</td><td>167</td><td>209</td><td>97</td></tr></table>$\bar{d} = 96.5$ $s = 103.2$ $n = 10$
$t = \frac{96.5 - 0}{103.2/\sqrt{10}} = 2.96$
df = 9 cv = 2.821
2.96 > 2.821
Reject H_o
Significant evidence to suggest Robusta produces a higher mean/average yield of green beans.
Or
Scientist's belief supported by given data</td><td>B1
M1
m1dep
B1
m1
A1
B1
E1dep</td><td>8</td><td>Hypotheses
Differences (consistent with H_1)
At least 5 correct differences
Attempt to evaluate $\bar{d}$ and s
Use of $\frac{s}{\sqrt{n}}$ ft in ts $n = 9$ or 10
Method for t
(±) 2.96 (2.85 – 3.05) or p=0.008
for correct cv or p = 0.00803 < 0.01
gains M1m1B1m1A1B1
correct conclusion in context 1 tail</td></tr>
<tr><td>(b)(i)</td><td>H_0 $\eta_{\text{difference}} = 0$
H_1 $\eta_{\text{difference}} \neq 0$ 2 tail 10%
<table><tr><td></td><td>R</td><td>S</td><td>T</td><td>U</td><td>V</td></tr><tr><td>d</td><td>5</td><td>-4</td><td>7</td><td>-8</td><td>- 6</td></tr><tr><td>rank</td><td>+ 4</td><td>- 2½</td><td>+ 6</td><td>- 7½</td><td>- 5</td></tr><tr><td></td><td>W</td><td>X</td><td>Y</td><td>Z</td><td></td></tr><tr><td>d</td><td>0</td><td>-2</td><td>4</td><td>-8</td><td></td></tr><tr><td>rank</td><td>.</td><td>- 1</td><td>+ 2½</td><td>- 7½</td><td></td></tr></table>$T_+ = 4 + 6 + 2½ = 12½$
$T_- = 2½ + 7½ + 5 + 1 + 7½ = 23½$
ts = 12½ n = 8
cv = 6
Accept H_o.
There is insufficient evidence (oe), at the 10% level, to suggest that there is a difference in the average taste score assigned by the two tasters.</td><td>B1
M1
m1
m1
A1
B1dep
E1dep</td><td>7</td><td>Hypotheses or use of $\mu_{\text{difference}}$
Can use d as subscript
Differences (either way)
Ranks with 1 for lowest |rank| zero must be ignored.
Sum of + or – ranks
Either total correct
cv=6 compared with lower T
or cv =30 compared with upper T
dep differences and correct ranking
Correct conclusion in context</td></tr>
<tr><td>(b)(ii)</td><td>1 + 2 + ….. + 9 = 45</td><td>M1
A1</td><td>2</td><td>Summation effort
Correct cao</td></tr>
<tr><td></td><td>Total</td><td></td><td>17</td><td></td></tr>
</table>

Q2	Solution	Marks	Total	Comments
(a)	0.052 +0.041 + …. +0.045 = 0.466 0.466 / 10 = 0.0466 Est st dev = 0.4299 × 0.0466 = 0.020 **AG**	M1 B1 A1	**3**	Totalling ranges/10 PI 0.4299 ×mean range ft ag
(b)(i)	$0.750 \pm 1.96 \times \frac{0.020}{\sqrt{5}}$ = 0.732 , 0.767(5) WL $0.750 \pm 3.09 \times \frac{0.020}{\sqrt{5}}$ = 0.722 , 0.778 AL	M1 m1ft A1 A1		$\sqrt{5}$ used(all other marks dep on this) Formula for control limits correct with 1.96 and 3.09 used ft 'their sd from (a) Warning 0.732/3 0.767/8 awrt Action 0.722 0.777/8 awrt
(ii)	0.15 × 0.020 = 0.003 0.35 × 0.020 = 0.007 1.67 × 0.020 = 0.033 2.15 × 0.020 = 0.043	M1 A1	**6**	Correct E values seen and × 0.020ft PI Allow correct to 3 dp
(c)	Means all within LWL and UWL. (Sample 9 mean is close to Upper Warning line)	E1	**1**	Mean all within **warning lines** dep (b)(i)(ii) used *n* =5
(d)	Sample 11 mean = 0.772 s = 0.0247 Sample 12 mean = 0.749 s = 0.0433	M1 A1		Effort to find mean and s At least one mean and one st dev correct awrt means 0.77, 0.75 sd 0.025, 0.043
(i)	Mean lies between UWL and UAL. Take another sample immediately.	E1 dep E1 dep		Mean between UWL/UAL Take another sample
(ii)	s lies above UAL. Stop production immediately.	E1 dep E1 dep	**6**	Standard deviation is beyond UAL Stop production dep (b)(i)(ii) correct. Condone small slip ft small slip in mean and sd in
	Total		**16**	

<table>
<tr><th>Q3</th><th>Solution</th><th>Mark</th><th>Total</th><th>Comment</th></tr>
<tr><td>(a)(i)

(ii)</td><td>The experiment is double blind, as neither experimental units (cyclists) nor researchers (engineers) are told (know) which lubricant is being tested.
or Only Heather knows which lubricant is being used.

Cyclist will have no particular expectations for a particular ride (ensures that cyclists will put the same amount of effort into each ride.)

It also ensures that the engineers will not handle the bikes differently, or treat the cyclists differently.</td><td>E1
E1

E1

E1</td><td>4</td><td>Double blind explained (neither know)
Full context used (inc lubricant)

No effect on cyclists, explained clearly.

Allow E1 for ‘may affect outcome if they knew/no effect on outcome’

No effect on engineers, explained clearly</td></tr>
<tr><td>(b)(i)

(ii)

(iii)</td><td>Completely randomised design

Latin square design

There are two nuisance/blocking factors (cyclist and ride order), which the Latin square design is able to handle.

e.g.
Cyclist
Ride order
<table><tr><td></td><td>A</td><td>B</td><td>C</td><td>D</td></tr><tr><td>1</td><td>L1</td><td>L3</td><td>L4</td><td>L2</td></tr><tr><td>2</td><td>L3</td><td>L1</td><td>L2</td><td>L4</td></tr><tr><td>3</td><td>L4</td><td>L2</td><td>L3</td><td>L1</td></tr><tr><td>4</td><td>L2</td><td>L4</td><td>L1</td><td>L3</td></tr></table></td><td>B1

B1

E1

B1

B1</td><td>5</td><td>

Dep on Latin Square stated

sc1 Ride order overlooked and used Rand Block

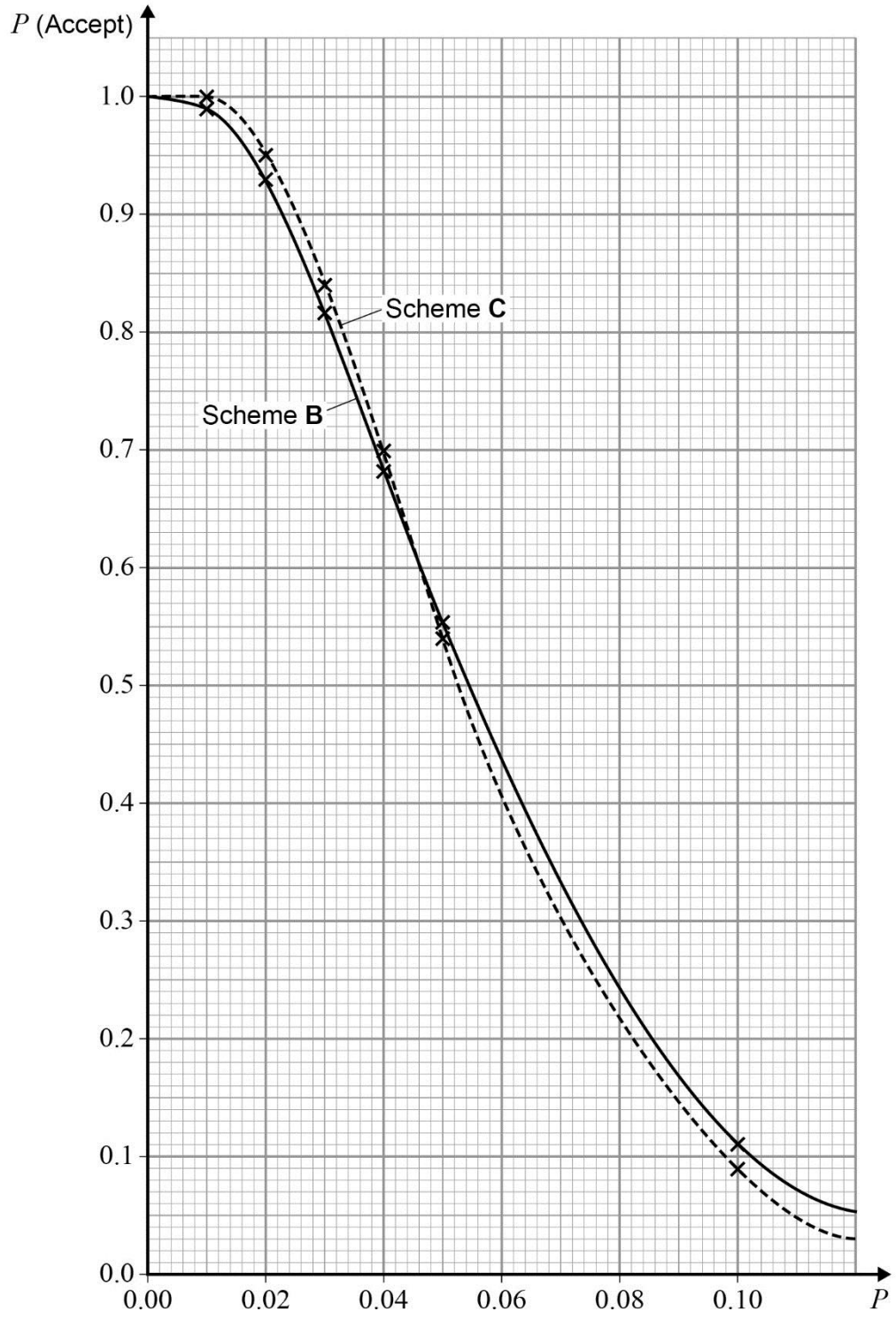
At least one row or column title must be ‘cyclist’ or ‘ride’ or equivalent. Rides may be split by day and morning/afternoon.

Correct Latin square design with no more than one of each treatment in a single row or column.</td></tr>
<tr><td>(c)</td><td>ANOVA</td><td>B1</td><td>1</td><td></td></tr>
<tr><td></td><td>Total</td><td></td><td>10</td><td></td></tr>
</table>

Q4	Solution	Mark	Total	Comment
(a)	$X =$ number of non-conforming baseballs in the sample.			
	$X \sim B(20,p)$ $p = 0.01$	M1		Use of $X \sim B(20,p)$ $p = 0.01$, $p = 0.10$ PI
	$P(\text{acceptance}) = P(X = 0) = 0.818$ $P(\text{rejection}) = 1 - P(X = 0) = 1 - 0.818$ $= 0.182$	A1		0.182 , 0.818
	(Above 2% so does not satisfy manufacturer)			
	$X \sim B(20,p)$ $p = 0.10$			Award M1 here for $X \sim B(20,p)$ p=0.1 if not gained above
	$P(\text{acceptance}) = P(X = 0) = 0.122$	A1		0.122, 0.878
	(Above 12% so does not satisfy S League)			
	0.182 > 0.02 and 0.122 > 0.12	E1	**4**	Both comparisons correct 0.182 > 0.02 0.122 > 0.12 (oe 0.818<0.98 and 0.878<0.88) or in words
(b)(i)	$X \sim B(50,p)$ $p = 0.01$	M1		For $X \sim B(50,p)$ n=50 ($p = 0.01$ or $p = 0.10$)
	$P(\text{acceptance}) = P(X \leq 2) = 0.986$	A1		awrt 0.986 (or 0.014)
	$X \sim B(50,p)$ $p = 0.10$ $P(\text{acceptance}) = P(X \leq 2) = 0.112$	A1	**3**	awrt 0.112
(b)(ii)	$P(\text{rejection}) = 1 - P(X \leq 2) = 1 - 0.986$ $= 0.014$ 0.014 < 0.02 [0.986>0.98] (Below 2% so does satisfy manufacturer)			
	0.112 < 0.12 [0.888>0.88] (Below 12% so does satisfy Surrey League)	E1	**1**	Both comparisons made

(c)	$X \sim B(40,p)$ $p = 0.01$ $P(\text{acceptance})$ = P ($X \leq 1$) or P ($X = 2$) × P ($X \leq 1$) or P ($X = 3$) × P ($X = 0$) $= 0.939 + (0.053 \times 0.939) +$ (0.007×0.669) = 0.993 or 0.994	M1 M1 m1 A1	**4**	Effort at double sample scheme (more than 1 **prob** summed) P ($X \leq 1$) **or** any other relevant probs Any correct probabilities seen. Correctly formed expression PI 0.993 – 0.994
(d)	On Figure 1	M1 B1 B1 A1	**4**	Both lines through (0,1) Scheme B plotting effort – at least 3 points correct Scheme C plotting effort – at least 3 points correct Both plots accurate and labelled
(e)	Scheme C preferred as • higher chance of accepting 'good' batches (p = 0.01,.02,.03,.04) • it may involve less sampling (40 when only 1 sample required compared to 50 for Scheme C)/fewer samples • Gives opportunity to select second sample for clarification when quality uncertain. Scheme B preferred as: • it is simpler • only ever samples 50 whereas Scheme C may require sampling 80	E1E1 (E1E1)	**2**	Allow 'Schemes very similar so little to choose between them' for E1 Max 2 marks
	Total		**18**	

Figure 1


P (Accept)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.00
0.02
0.04
0.06
0.08
0.10
P
Scheme C
Scheme B

Q5	Solution	Marks	Total	Comments
	H_O $\mu_{none} = \mu_{T1} = \mu_{T2}$ H_1 at least 2 (of the means) differ 1% 1 tail	B1		Suffices must be identified Disallow 'At least one differs'
	None 820, 940, 930, 880, 860, 790, 850 — **TR_1** 720, 900, 790, 920, 840, 870, 810, 900, 840 — **TR_2** 650, 710, 690, 710, 620, 700, 830	M1 m1		Effort to separate categories of treatment PI 12 or more correctly placed PI
	$T_{none} = 6070$ $T_{TR1} = 7590$ $T_{TR2} = 4910$ $n_{none} = 7$ $n_{TR1} = 9$ $n_{TR1} = 7$	m1		Total in each category effort
	T= 18570 $\sum\sum x_{ij}^2 = 15184700$ N= 23	m1		T and $\sum\sum x_{ij}^2$ effort
	Total SS $15184700 - \frac{18570^2}{23} = \underline{191443.5}$	m1		ss Total
	Treatments SS $\frac{6070^2}{7}+\frac{7590^2}{9}+\frac{4910^2}{7} - \frac{18570^2}{23} = 115214.9$			
	ss / **df** / **ms** **Between treats** 115214.9 / **2** / 57607.5 **Error** 76228.6 / **20** / 3811.4 **Total** 191443.5 / 22	m1		ss Error (allow small slip – not if negative)
		B1		df Between Treats and Error - BOTH
		m1		ms Error and Between dep correct df
	$F = \frac{57607.5}{3811.4} = 15.11$ $F_{20}^{2} = 5.849$	M1 A1		*F* Between divided by Error awfw 15.0 - 15.3 condone small arithmetic slips if *F* in range or $p = 0.0001$
	15.11 > **5.849** Reject H_o	B1		cv=5.849 cao or p = 0.0001 < 1%

	The conclusion indicates that there is a **significant difference** between the **mean** level of **immune cells** …… ..for at least two of the treatments/treatment **TR_2** clearly reduces the level of immune cells/ slows the progress of the disease more than treatment **TR_1**	E1dep E1dep	**14**	Correct conclusion in context mention of 'at least two' treatments or **TR_2** identified as treatment that reduces more than **TR_1**
	Total		**14**	
	TOTAL		**75**	