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General Certificate of Education (A-level)
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Statistics SS06

(Specification 6380)

Statistics 6

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)	Apples not treated with chemical	E1	1	Need not chemical
(b)	To eliminate bias / reduce expt error – avoid 'best' apples being selected for chemical treatment for example	E1	1	So they would not have started to ripen thus chemical only factor involved
(c)	2 factor analysis of variance	E1,1	2	E1 2 factor, E1 anova SC Latin Square B1
(d)	The variety of apple	E1	1	
	Total		**5**	

Q	Solution	Marks	Total	Comments
2(a)	Plan A Binomial $n = 30$ $p = 0.15$			
	$P(X \leq 1) = 0.048 < 0.05$	B1		For 0.048
	Plan B Binomial $n = 50$ $p = 0.15$			
	$P(X \leq 3) = 0.046 < 0.05$	B1		For 0.046
	Each plan meets requirement	E1	3	For comparison 0.05 or explanation meets requirement
(b)(i)	1% $p = 0.01$			
	Plan A $P(X \leq 1) = 0.964$	M1		$P(X \leq 1$ and 3) or 1% and 2%
	Plan B $P(X \leq 3) = 0.998$	A1		Any two
(ii)	2% $p = 0.02$			
	Plan A $P(X \leq 1) = 0.880$			
	Plan B $P(X \leq 3) = 0.982$	A1	3	All four
(c)(i)	Plots	M1 A1	 2	Correct attempt (at least 6) Accurate, points joined and through (0, 1)
(ii)	Plan B has a higher probability of acceptance for (good quality) batches with both 1% and 2% non-conforming	E1		
	Plan A better at rejecting high level non-conforming at 10% or both same / Plan B better at rejecting at 15%	E1	2	Any 2 points made OE
	Plan A has smaller sample size			
(d)(i)	Plan C			
	$P(Acc) = P(X = 0) + P(X = 1) \times P(X \leq 1)$	M1		
	$= 0.0388 + (0.1368 \times 0.1756)$	m1		Use of B(20, 0.15) seen 0.038/9, 0.136/7, 0.175/6
	$= 0.0628$	A1	3	Attempt at 2 sample probs mult 0.062–0.063
(ii)	Advantage – sample size might be smaller most of time ($n = 20$) than that for Plan A and will always be smaller than for Plan B	E1		Advantage On average / usually smaller sample size
	Disadvantage – Plan C prob of acceptance for $p = 0.15$ is above requirement or Plan C more complicated / time consuming	E1	2	Disadvantage Need to be labelled as adv or disadv
	Total		**15**	

Q	Solution	Marks	Total	Comments
3(a)(i)	H_0 pop mean diff $\mu_d = 5$ H_1 pop mean diff $\mu_d > 5$ 1 tail 10%	B1		H_0 pop mean diff $\mu_d = 5$ H_1 pop mean diff $\mu_d < -5$ H_1 must be consistent with d
	d = Brand – Sup Own **1** +7, **2** +13, **3** –1, **4** +6, **5** –4 **6** +16, **7** +1, **8** +5	M1		Differences (can be reversed)
	$\bar{d} = 5.375$ $s = 6.781$ $n = 8$	m1		Attempt to find $\bar{d}$, s can be implied by correct ts
	$t = \dfrac{5.375 - 5}{6.781/\sqrt{8}} = 0.156$	M1		Use of $\dfrac{s}{\sqrt{8}}$ ft
		M1 m1 A1		Use of $\bar{x} - 5$ or $\bar{x} + 5$ Whole method for t (±)0.156 (0.15–0.16) SC $t = -4.3275$ B3
	df = 7 |cv| = 1.415	B1		For correct consistent cv CAO
	0.156 < 1.415 Accept H_0 Significant evidence to suggest that claim is correct.	E1	9	Clear correct conclusion in context of claim or jam contents
(ii)	Assumed that differences in jar jam contents are normally distributed and samples of jars are obtained at random.	E1 E1	2	Diffs of contents / jam normal Jars obtained at random
(b)(i)	Cannot assume scores are normally distributed as tasters are untrained or no guidance given for sweetness scores.	E1	1	
(ii)	H_0 $\eta_{\text{difference}} = 0$ difference (supermarket –brand) H_1 $\eta_{\text{difference}} > 0$ 1 tail 5%	B1		Must be consistent
	Signs + + + – + + + +	M1		
	$7^+ / 1^-$ signs – test values	A1		ts correct and identified or seen used
	Binomial (8, 0.5) model $P(\geq 7+) = P(\leq 1-) = 0.035 < 0.05$ for one tail test	M1		Correct probability compared with 0.05 or cr with probs
	Reject H_0. There is sufficient evidence, at the 5% level, to suggest that the claim is correct or supermarket jam is sweeter.	E1	5	Correct conclusion in context Allow W S-R B1, M1, A1, M1, E1 as sign differences: 22, 21, 9, –2, 11, 13, 8, 12 ranks + 8, 7, 3, 4, 6, 2, 5 $T_+ = 35$ – 1 $T_- = 1$ cv = 6 $T_- < 6$ reject H_0
	Total		**17**	

Q	Solution	Marks	Total	Comments
4(a)(i)		B1 M1		For 1.96, 3.09 For $0.02/\sqrt{4}$
	Warning $2.00 \pm 1.96 \times 0.02/\sqrt{4}$ (1.98, 2.02)	A1		Warning correct both
	Action $2.00 \pm 3.09 \times 0.02/\sqrt{4}$ (1.97, 2.03)	A1		Action correct both
(ii)	Ranges $0.02 \times 0.199 = 0.0040$ 0.004 $0.02 \times 0.595 = 0.0119$ 0.012 $0.02 \times 3.984 = 0.0797$ 0.080 $0.02 \times 5.309 = 0.1062$ 0.106	M1 A1	6	D values correct $\times 0.02$ AWRT or truncated 3dp
(b)(i)	Sample 6 Sample 7 Sample 8 $\bar{x}$ 1 –1 –0.75 Range 4 3 7	A1 A1	2	One mean and range correct or all 3 means / ranges All means and ranges correct
(ii)	Ranges all OK (0.01–0.07) Mean sample 10 = 2.0225 (or 2.25)	E1 E1	2	Ranges considered OK Mean values considered Sample 10 a problem or identified
(iii)	Mean of sample 10 lies between upper warning and action lines. Take another sample immediately	E1 B1	2	Reason Take sample (B1 if no correct reason given) SC Beyond warning, take another sample B1
(c)(i)	$P(1.975 < X < 2.025) = (-0.75 < Z < 1.75)$ $= 0.733$ Outside tolerances 0.267	M1 A1	2	–0.75 and 1.75 or 0.733 0.26–0.27
(ii)	Range of tolerances = 2.025 – 1.975 = 0.05 $6 \times 0.02 = 0.12$ so range < 6σ or [less than 6] × sd Process will not meet tolerances	M1 E1	2	Consideration of 6σ and range Not meet with correct reason SC comment on 0.267 out of tol B1
	Total		**16**	

Q	Solution	Marks	Total	Comments
5(a)(i)	A(20/29) B(30/49) C(50+) $T_A = 10.67$ $T_B = 16.03$ $T_C = 16.39$ $n_A = 5$ $n_B = 6$ $n_C = 6$ T = 43.09 $\sum\sum x_{ij}^2 = 111.138$ N = 17 $\sum \frac{T_i^2}{n_i} = \frac{10.67^2}{5} + \frac{16.03^2}{6} + \frac{16.39^2}{6}$ $= 110.37$			
	$SS_{Ages} = 110.37 - \frac{43.09^2}{17}$ $= 1.148$	M1		SS for ages
	$SS_{Total} = 111.138 - \frac{43.09^2}{17}$ $= 1.917(5)$	M1		SS for total (can be implied in table)
		M1		Error SS ft (not –ve)
		m1		Method for MS (dep error ss/df)
	$F = \frac{0.574}{0.055} = 10.44$	m1 A1		Method for F (ft) 10.2–10.6 (or p =)
	$F_{14}^2 = 6.515 < 10.44$	B1 B1		df correct 2, 14 cv correct CAO allow $p = 0.00167$
	H_0 $\mu_A = \mu_B = \mu_C$ H_1 at least 2 of the pop means differ	B1		hypotheses – subscripts identified OE
	Reject H_0	A1	10	
(ii)	There is significant evidence of a difference in mean satisfaction scores for the 3 age groups so at least 2 groups differ. Ages 20/29 sig less satisfied than those aged 50+	E1	1	In context
(iii)	The normal populations of satisfaction scores have a common variance	E1	1	For either normally distributed satisfaction scores or populations of satisfaction scores have a common variance

	SS	df	MS
Ages	1.148	2	0.574
Error	0.769(5)	14	0.055
Total	1.9175	16	

Q	Solution	Marks	Total	Comments
5(b)	H_0 $\mu_{Run} = \mu_{Cycle} = \mu_{Swim}$			
	H_1 at least 2 of the means differ			
	$T_{Male} = 26.0$ $T_{Female} = 23.6$ $n_{Male} = 3$ $n_{Female} = 3$			
	$T_{Run} = 14.7$ $T_{Cycle} = 17.5$ $T_{Swim} = 17.4$ $n_{Run} = 2$ $n_{Cycle} = 2$ $n_{Swim} = 2$			
	T = 49.6 $\sum\sum x_{ij}^2 = 413.78$ N = 6			
	Total SS			
	$413.78 - \frac{49.6^2}{6} = 3.753$	M1		Total SS method (can be implied in table)
	Sex SS			
	$\frac{26.0^2}{3} + \frac{23.6^2}{3} - \frac{49.6^2}{6} = 0.96$	M1		Sex SS method
	Sport SS			
	$\frac{14.7^2}{2} + \frac{17.5^2}{2} + \frac{17.4^2}{2} - \frac{49.6^2}{6} = 2.523$	M1		Sport SS method
		M1		Error SS ft (not –ve)
		B1		Error df correct $\upsilon = 2$
		m1		Method for MS ft (dep SSe)
		m1		Method (dep prev Ms) for F (sex/error or sport/error) Not –ve
	$F = \frac{1.26}{0.135} = 9.35$ $F_{2}^{2} = 19.0$	A1		Sports F correct 9.2–9.5
	$9.35 < 19$ Accept H_0	B1		cv correct CAO or $p = 0.117$
	There is no significant evidence of a difference in mean training times for the the 3 sports.	E1	10	Correct conclusion in context, ft small arithmetic error in F
	Total		**22**	
	TOTAL		**75**	

	SS	df	MS
Sex	0.96	1	0.96
Sport	2.523	2	1.26
Error	0.27	2	0.135
Total	3.753	5	