Version 1.0

General Certificate of Education
June 2010

Statistics SS06

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 meeting attended by all examiners and is the scheme which was used by them in this examination. The standardisation meeting 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 the standardisation meeting each examiner analyses a number of candidates' scripts: alternative answers not already covered by the mark scheme are discussed at the meeting and legislated for. If, after this meeting, examiners encounter unusual answers which have not been discussed at the meeting they are required to refer these to the Principal Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of candidates' 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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Key to mark scheme and abbreviations used in marking

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	MC	mis-copy
CAO	correct answer only	MR	mis-read
CSO	correct solution only	RA	required accuracy
AWFW	anything which falls within	FW	further work
AWRT	anything which rounds to	ISW	ignore subsequent work
ACF	any correct form	FIW	from incorrect work
AG	answer given	BOD	given benefit of doubt
SC	special case	WR	work replaced by candidate
OE	or equivalent	FB	formulae book
A2,1	2 or 1 (or 0) accuracy marks	NOS	not on scheme
–*x* EE	deduct *x* marks for each error	G	graph
NMS	no method shown	c	candidate
PI	possibly implied	sf	significant figure(s)
SCA	substantially correct approach	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. However, there are situations in some units where part marks would be appropriate, particularly when similar techniques are involved. Your Principal Examiner will alert you to these and details will be provided on the mark scheme.

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.

SS06

Q	Solution	Marks	Total	Comments
1(a)	Randomised block.	B1	1	
(b)	Each document type is scanned by each scanner model in Design 3. In Design 2, document types are unevenly spread amongst scanner models eg Scanner X does not scan a Document 3.	E1	1	
(c)	Each scanner model only scans one type of document so the overall performance of the scanner cannot be fairly judged.	E1	1	or Document variation might be confused with scanner variation
(d)	2 factor ANOVA	B1	1	Or equivalent
	Total		**4**	

SS06 (cont)

Q	Solution	Marks	Total	Comments
2(a)	$300 \pm 1.96 \times \frac{1.6}{\sqrt{5}}$ (298.6 , 301.4) W	B1		For 1.96 and 3.09
		M1		For $300 \pm z \times$ sd
	$300 \pm 3.09 \times \frac{1.6}{\sqrt{5}}$ (297.8 , 302.2) A	M1		For sd correct $\frac{1.6}{\sqrt{5}}$
		A1	4	Correct to 1dp
(b)	5.484 × 1.6 = 8.8 (8.77) 4.197 × 1.6 = 6.7 (6.72) 0.850 × 1.6 = 1.4 (1.36) 0.367 × 1.6 = 0.6 (0.59)	M1		D × 1.6 ($n = 5$)
		A1	2	All correct to 1 dp
(c)(i)	$\bar{X}$ = 297.5 range = 2.9			
	Range OK but mean below lower action limit.	B1		For mean and range attempted
	Stop production	E1		ft if mean and range found
(ii)	$\bar{X}$ = 300.8 range = 6.8			
	Mean OK but range between upper warning and action limits.	B1		For mean and range attempted
	Take another sample immediately.	E1	4	ft if mean and range found **SC** in (c) B1 if **only** mean or **only** range found)
	Total		**10**	

SS06 (cont)

Q	Solution	Marks	Total	Comments
3(a)	H_o pop mean diff $\mu_d = 0$ H_1 pop mean diff $\mu_d \neq 0$ 2 tail 5%	B1		Pop mean used
	d = A – B pers 1 2 3 4 5 d 88 51 0 40 303 pers 6 7 8 9 10 d -107 24 31 315 112	M1		differences
	$\bar{d} = 85.7$ $s = 131.3$ $n = 10$	m1		Use of $\frac{s}{\sqrt{n}}$
	$t = \frac{85.7 - 0}{131.3/\sqrt{10}} = 2.06$ (2.0646)	m1 A1		Method for t ± 2.065 (2.060 – 2.067) or p = 0.0690
	df = 9 cv = ± 2.262 2.06 < 2.262 OE	B1 B1		9 df for correct cv
	Accept H_o No significant evidence to suggest a difference between the mean amounts of pizza eaten for types A and B.	A1 E1	9	correct conclusion context ft
(b)	Difference between amounts of pizza eaten are normally distributed.	E1	1	
(c)	Sensible idea as amounts of pizza eaten seem erratic (person 3 ate none). Range of amounts 422 but sd 131.6. Quite a large sd for that range if normally dist.	E1	1	Sensible attempt at justification.
(d)	H_o pop median diff $\eta_d = 0$ H_1 pop median diff $\eta_d \neq 0$ 2 tail 5%	B1		Pop median used
	8^+ / 1^-	M1		for signs or signed differences
	$P(\leq 1^-) = 0.0195 < 0.025$	M1		comparison with correct bin prob
	Significant evidence to reject H_o. Conclude that there is a difference in the average amounts of pizza eaten. (Pizza type A preferred)	A1 E1	5	correct conclusion or critical region found context
(e)	Normal assumption may not be valid so sign test more appropriate and conclude that there is a difference in the popularity of the pizza types (Type A preferred).	E1 E1	2	or refer to more powerful t test using all numerical data so conclusion in part (a) more appropriate. No difference in popularity detected. [Not conclusions repeated]
	Total		**18**	

SS06 (cont)

Q	Solution	Marks	Total	Comments
4(a)(i)	$z = \frac{93-91}{3.1/\sqrt{10}} = 2.04$	M1		$3.1/\sqrt{10} = 0.980$
	$P(z > 2.04) = 0.0207$	m1		$z = \frac{93-\mu}{0.980}$ once
(ii)	$z = \frac{93-94}{3.1/\sqrt{10}} = -1.02$	m1		
	$P(z > -1.02) = 0.846$	A1	4	
(b)	$P(\bar{X} < x) < 0.10$			
	$\frac{x-94}{3.1/\sqrt{8}} < -1.2816$	B1		-1.2816
		M1		$3.1/\sqrt{8}$
	$x < 94 - 1.2816 \times \frac{3.1}{\sqrt{8}}$	M1		correct method
	$x < 92.595$	A1	4	x =(92.5 – 92.6)
(c)	Type I error is to reject a batch as being below the quality required when the batch is of acceptable quality.	B1		Type I error correct.
	(good batch rejected)	E1	2	'Producer's Risk' in context.
	Total		**10**	

SS06 (cont)

Q	Solution	Marks	Total	Comments
5.(a)	P(≤ 2) $n = 50$ p: 0.01 | 0.05 | 0.10 | 0.15 P(acc): 0.986 | 0.541 | 0.112 | 0.014	M1 A1	2	Allow 2dp
(b)	Smooth curve through the points (0, 1), (0.01, 0.986), (0.05, 0.541), (0.10, 0.112), (0.15, 0.014)	M1A1	2	Plot (must go through (0,1))
(c)	P(acc) = P(0) + P(1) × P(0,1) = 0.0424 + 0.1413 × 0.1837 = 0.068	M1 M1 A1	3	
(d)	Smooth curve through the points (0, 1), (0.01, 0.956), (0.05, 0.402), (0.1, 0.068), (0.15, 0.010)	B1	1	plot
(e)(i)	A – simpler or -higher chance of accepting good quality batches	E1		
	B – better at rejecting batches with higher % non-conforming but still has 96% probability of accepting good quality batches. - smaller average sample size likely.	E1		
(ii)	Cost Ease of use Ability to reject poor quality batches/ accept good quality batches	B1 B1	4	Any two
	Total		**12**	

SS06 (cont)

Q	Solution	Marks	Total	Comments
6(a)	$T_{Calm} = 6.97 \quad T_{Windy} = 5.95 \quad T_{V\,Windy} = 4.01$ $n_{Calm} = 7 \quad n_{WIndy} = 9 \quad n_{V\,Windy} = 7$			
	$\sum\sum x_{ij}^2 = 14.6067 \qquad N = 23$			
	$\sum \frac{T_i^2}{n_i} = \frac{6.97^2}{7} + \frac{5.95^2}{9} + \frac{4.01^2}{7} = 13.171$			
	$SS_{Winds} = 13.171 - \frac{16.93^2}{23} = 0.70894$	M1		Winds SS
	$SS_{Total} = 14.6067 - \frac{16.93^2}{23} = 2.1447(5)$	M1		Total SS
		M1		Error SS ft
		m1		Method for MS $\rightarrow$ dep on df correct
	$F = \frac{0.35447}{0.07179} = 4.94$	m1		Method for F
		A1		4.50 – 5.00 (or p = 0.081)
	$H_O \ \mu_c = \mu_w = \mu_{vw}$ H_1 at least 2 of the means differ	B1		For hypotheses
	$F_{20}^{2} = 3.493 \qquad 4.94 > 3.493$	B1 B1		df correct for cv correct
	Reject H_O. There is significant evidence of a difference in mean iron pollution for the 3 average wind speeds. (greater pollution when calm than when very windy)	A1	10	
(b)(i)		M1		Totals attempted for temps
	total $T_1 = 2.32 \quad T = 7.16$ total $T_2 = 2.31$ total $T_3 = 2.53$			
	$\sum \frac{T_i^2}{n_i} = \frac{2.32^2}{3} + \frac{2.31^2}{3} + \frac{2.53^2}{3} = 5.7065$	M1 A1		SS attemped 0.006 – 0.014
	$SS_{temps} = 5.7065 - \frac{7.16^2}{9} = 0.01029$	m1		Error SS ft
		B1		df correct for Humidity, Temps & Error
		A1	6	any F correct (22.0 – 23.0) (0.62 – 0.72)

	SS	df	ms
Winds	0.70894	2	0.35447
Error	1.43581	20	0.07179
Total	2.1447(5)	22	

	SS	df	ms	F
Winds	0.34682	2	0.17341	22.59
Humidity	0.01056	2	0.00528	0.69
Temps	0.01029	2	0.00514	0.67
Error	0.01535	2	0.00765	
Total	0.38302	8		

SS06 (cont)

Q	Solution	Marks	Total	Comments
6(b)(ii)	H_O $\mu_c = \mu_w = \mu_{vw}$ H_1 at least 2 of the means differ $F_{2}^{2} = 19$ $22.59 > 19$ Reject H_O. There is significant evidence of a difference in mean iron pollution for the 3 average wind speeds.	B1 M1 A1	3	for cv correct F ts comparison in context
6(b)(iii)	Test stats $F_{\text{Humidity}} = 0.69$ $F_{\text{Temps}} = 0.67$ $F_{2}^{2} = 19$ cv Both ts < 19 so not effective blocking factors	B1 E1	2	Identification of relevant ts and cv – can be implied Not effective as not significant
	Total		**21**	
	TOTAL		**75**	