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General Certificate of Education (A-level)
June 2011

Statistics SS05

(Specification 6380)

Statistics 5

Final

Mark Scheme

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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.

SS05 – June 2011

Q	Solution	Marks	Total	Comments
1	s = 19.832	B1		19.8 (19.8 ~ 19.9) or 393 or 4326 (3SF)
	$H_0 : \sigma = 25$ $H_1 : \sigma \neq 25$	B1		hypotheses
	$\sum \frac{(x-\bar{x})^2}{\sigma^2} = \frac{11 \times 19.832^2}{25^2}$ $= \frac{4326.25}{625}$	M1		
	$= 6.92$	A1		$6.92\ (6.91 \sim 6.93)$
	c.v. χ^2_{11} 3.816 and 21.920	B1 B1		11 df 3.816
	accept H_0 no significant evidence to doubt that the weights of the pieces of fudge are distributed with a standard deviation of 25 g	A1		conclusion – allow comparison with lower tail in context – disallow contradiction
	c.i. 14.05 ~ 33.67 *Using* F *ts 1.589 c.v. 0.5017 and 2.883* *ts 0.629 c.v. 0.3469 and 1.993* *p = 0.390*			
	Total		**7**	

SS05 (cont)

Q	Solution	Marks	Total	Comments
2(a)(i)	<table><tr><th>Time interval</th><th>O</th><th>E</th></tr><tr><td>8 am – 11 am</td><td>19</td><td>11.67</td></tr><tr><td>11 am – 1 pm</td><td>3</td><td>7.78</td></tr><tr><td>1pm – 3 pm</td><td>6</td><td>7.78</td></tr><tr><td>3 pm – 5 pm</td><td>7</td><td>7.78</td></tr></table>	M1 A1		method for E values all E values correct (1dp)
	H_0 : rectangular distribution is an adequate model H_1 : rectangular distribution is not an adequate model	B1		hypotheses – may be earned in conclusion
	$\sum \frac{(O-E)^2}{E} = \frac{7.33^2}{11.67} + \frac{4.78^2}{7.78} + \frac{1.78^2}{7.78} + \frac{0.78^2}{7.78}$	M1		attempt at $\sum \frac{(O-E)^2}{E}$ using their E values
	$= 8.03$	A1		$(8 \sim 8.05)$
	c.v. χ_3^2 is 6.251	B1 B1F		3 df (7.815, 9.348, 11.345, 12.838) 6.251 – their df (4.605, 7.779)
	significant evidence that the rectangular distribution does not adequately model the distribution of daily times of false fire alarms	A1F A1F	9	conclusion – needs correct method for their E values and comparison with upper tail in context – needs previous A mark
(ii)	if John's belief was correct a rectangular distribution would provide an adequate model	E1		rectangular distribution would support John's belief
	there is significant evidence to reject the rectangular distribution and hence to reject John's belief	E1F	2	belief not supported
(b)(i)	number of alarms between 3pm and 5pm slightly less than expected – hence no evidence to support Folake's belief (number between 4pm and 5pm unknown)	E1 E1	2	comparison of O and E between 3pm and 5pm no support for Folake's belief
(ii)	inappropriate since E for a single hour would be 3.89, ie <5 and so test would be invalid	E1 E1	2	because E<5 test invalid
(c)	there are many more false alarms than expected during the first 3 working hours	E1	1	more than expected during first 3 hours; ignore additional comments
	Total		**16**	

SS05 (cont)

Q	Solution	Marks	Total	Comments
3(a)(i)	s = 20.542	B1		20.542 $(20.5 \sim 20.6)$ or 422.0 $(421.5 \sim 422.5)$ or 4219.6 $(4215 \sim 4225)$
	95% confidence interval for standard deviation given by			
	$3.247 < \frac{10 \times 20.542^2}{\sigma^2} < 20.483$	M1		any correct expression – condone one small slip; condone incorrect χ^2
	$\frac{4219.64}{20.483} < \sigma^2 < \frac{4219.64}{3.24}$	m1		correct expression – condone incorrect χ^2
	$206.01 < \sigma^2 < 1299.55$	B1		10 df
		B1F		3.247 $(3.24 \sim 3.25)$ and 20.483 $(20.4 \sim 20.5)$
		m1		correct method for interval for σ (or σ^2) provided it is clearly called σ^2 or variance
	$14.4 < \sigma < 36.0$	A1	7	14.4 $(14.3 \sim 14.4)$ and 36.0 $(36.0 \sim 36.1)$
(ii)	$\bar{x} = 61.1818$			
	95% confidence interval for mean			
	$\frac{61.1818 \pm 2.228 \times 20.542}{\sqrt{11}}$	M1		use of their $\frac{s}{\sqrt{11}}$
		m1		method for interval; allow incorrect *t*-value
		B1		2.228 or 2.23
	61.18 ± 13.8			
	$47.4 \sim 75.0$	A1	4	47.4 (47.35 ~ 47.45) and 75.0 (74.95 ~ 75.05)
(b)	9.3 + 10% = 10.23	B1		10.23 (10.2 ~ 10.3) or 54.7
	this is below the lower interval of the confidence interval for the standard deviation	E1		below confidence interval for sd
	hence there is significant evidence that the standard deviation exceeds that for *Blandlager* by more than 10%	E1		sd increased by more than 10%
	although the sample mean of 61.2 suggests that the mean may be more than 10% greater than that for *Blandlager*, the confidence interval for the mean contains 49.7	E1		interval for mean contains 49.7/54.7
	so this provides no significant evidence that the mean is more than that for *Blandlager*	E1	5	no significant evidence that the mean has increased by 10% insufficient evidence to change to *Crudgiesale* (If no reference to c.i. in (a), maximum 2 marks) (Maximum 5 marks for this part)
	Total		**16**	

SS05 (cont)

Q	Solution	Marks	Total	Comments
4(a)	mean $\frac{1}{0.22} = 4.55$	M1		for both
	sd $\frac{1}{0.22} = 4.55$	A1	2	4.55 (4.54 ~ 4.55) for both
(b)	$e^{-0.22\times5}$	B1		0.22×5
	$= e^{-1.1}$	M1		allow wrong tail
	$= 0.333$	A1	3	0.333 (0.332 ~ 0.333)
(c)	$1 - e^{-0.22\times3}$	M1		attempt to find > or < 3 from exponential parameter 0.22
	$= 1 - e^{-0.66}$			
	$= 1 - 0.5168$	m1		allow wrong tail
	$= 0.483$	A1		0.483 (0.483 ~ 0.484)
(d)	$z = \frac{(3 - 4.545455)}{\left(\frac{4.545455}{\sqrt{40}}\right)}$	M1		Use of $\frac{\text{their sd}}{\sqrt{40}}$
	$= -2.15$	m1		z – their mean and sd from (a) – ignore sign
		m1		needs M1 from part (a) – allow wrong tail
	Probability mean time exceeds 3 minutes is 0.984	A1	4	0.984 (0.98 ~ 0.99)
	Total		**12**	

SS05 (cont)

Q	Solution	Marks	Total	Comments
5(a)(i)	$\bar{x}_{ABC} = 205.125 \quad s_{ABC} = 15.6245$	B1		205.125 and 15.6245 or 244.125
	$\bar{x}_{XYZ} = 192.429 \quad s_{XYZ} = 17.7844$	B1		192.429 and 17.784 or 316.29
				all correct to 3SF – must be shown but may be earned in (a)(ii)
	$H_0 : \sigma_{ABC} = \sigma_{XYZ}$ $H_1 : \sigma_{ABC} \neq \sigma_{XYZ}$	B1		hypotheses
	$F = \frac{316.29}{244.125} = 1.30$	M1		for F
		A1		1.30 (1.29 ~ 1.30)
	c.v. $F_{[6,7]}$ is 5.119	B1		6, 7 df
		B1		5.119 (5.11 ~ 5.12)
	(or compare 0.772 with 0.195) accept H_0 standard deviations of the times are the same for each courier *P = 0.7354 (0.735 ~ 0.736)*	A1F	8	conclusion in context
(ii)	pooled variance estimate $s_p^2 = \frac{(244.125 \times 7 + 316.271 \times 6)}{13}$	M1		method for pooled variance
	= 277.423			
	$H_0 : \mu_{ABC} = \mu_{XYZ} + 10$	B1		one hypothesis correct
	$H_1 : \mu_{ABC} > \mu_{XYZ} + 10$	B1		both hypotheses correct – don't penalise the same error twice
	$t = \frac{(205.125 - 192.429 - 10)}{\sqrt{277.423\left(\frac{1}{8} + \frac{1}{7}\right)}}$	M1 M1		method for numerator method for denominator allow $\frac{s_A^2}{8} + \frac{s_B^2}{7}$
	= 0.313	A1		0.313 (0.31 ~ 0.32); ignore sign
	c.v. t_{13} is 1.35	B1		1.35; ignore sign
	accept H_0 no significant evidence to show that *XYZ* couriers are more than 10 minutes faster than *ABC* couriers *P = 0.3797 (0.379 ~ 0.4)*	A1F A1F	9	accept H_0 – must be compared with correct tail of *t* – disallow contradiction conclusion in context – needs previous A mark
(b)(i)	standard deviation unchanged – not	E1		no change
+	affected by adding a constant	E1		sd unchanged by adding a constant
(ii)	in (a)(ii) there was no significant evidence that the mean time had been reduced by more than 10 minutes hence the firm will continue to use *ABC* couriers	E1		from (a)(ii) firm will continue with *ABC* – may be earned in (a)(ii)
	the additional information reduces the difference in the sample means from 12.7 minutes to 2.7 minutes and so offers no reason to change the decision	E1 E1	5	difference reduced no change to decision
(c)	*ABC* couriers - these times might be affected by weather conditions, holidays, road works etc	E1		Reason for *ABC* couriers
	XYZ couriers – these are times of a firm hoping for a contract so may not be representative of times if contract is won/new firm unfamiliar with route	E1	2	Reason for *XYZ* couriers
	Total		**24**	
	TOTAL		**75**	