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General Certificate of Education (A-level)
June 2012

Statistics SS05

(Specification 6380)

Statistics 5

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.

Q	Solution	Marks	Total	Comments
1(a)	$s^2 = 860.4$	B1	1	B1 860.4 (860~861)
(b)	90% confidence interval of s.d. given by $3.325 < 9 \times 860.4/\sigma^2 < 16.919$	M1 m1		M1 any correct expression – generous, allow slip (10 × s^2 9 × s) m1 completely correct expression - allow incorrect χ^2 values
	$7743.6/16.919 < \sigma^2 < 7743.6/3.325$	B1 B1		B1 9df B1 3.325 and 16.919
	$457.687 < \sigma^2 < 2328.902$	M1		M1 correct method for interval for σ (or σ^2 provided it is clearly called σ^2 or variance)
	$21.4 < \sigma < 48.3$	A1	6	A1 21.4 (21.35~21.45) and 48.3 (48.2~48.3)
(c)	60mm is above the upper limit of the confidence interval. It will not be necessary to allow for such a large standard deviation.	E1 E1√	2	E1 above confidence interval E1√ unnecessary
	Total		**9**	

Q	Solution	Marks	Total	Comments
2(a)(i)	mean 15 s.d. $30/\sqrt{12} = 8.66$	B1 M1 A1	 3	B1 15 cao M1 method for s.d. or variance A1 8.66 (8.65 ~ 8.7)
(ii)	$18/30 = 0.6$	M1 A1	 2	M1 method - allow wrong tail A1 0.6 acf
(b)(i)	$z = (12 - 10)/3.1 = 0.645$ $P(>12) = 1 - 0.741 = 0.259$	M1 A1	 2	M1 method - allow wrong tail A1 0.259 (0.257 ~ 0.262)
(ii)	Alan's waiting time is shorter on average and also less variable. His probability of having to wait more than 12 minutes is much less than Megara's	E1 E1	 2	E1 <u>average</u> wait shorter E1 less variable E1 prob >12 much less *maximum 2*
(c)	Megara's waiting time is now rectangular on [0,20] mean 10 s.d.$20/\sqrt{12} = 5.77$	M1 A1	 2	M1 rectangular [0,20] may be implied A1 10 and 5.77 (5.75~5.8)
	Total		**11**	
3(a)(i)	mean = 1/0.0045 = 222.2	M1 A1	 2	M1 method A1 222 (222~222.4)
(ii)	probability will wear the suit in next 100 days $= 1 - e^{-0.45}$ $= 1 - 0.638 = 0.362$	M1 m1 A1	 3	M1 100×0.0045 m1 method - allow wrong tail A1 0.362 (0.362~0.363)
(iii)	probability will not wear suit for a year = $e^{-365\times0.0045}$ $= e^{-1.6425}$ $= 0.193$	M1 A1	 2	M1 method - allow wrong tail A1 0.193 (0.193~0.194)
(b)	mean = 365×0.0045 = 1.64	M1 A1	 2	M1 method A1 1.64 (1.64~1.65)
(c)	number of times per year which Imran wears a suit is Poisson mean 1.64 + 1.72 = 3.36	B1 B1	 2	B1 Poisson, mean 1.72 + their (b) B1 3.36 (3.36~3.37)
	Total		**11**	

Q	Solution	Marks	Total	Comments
4(a)(i)	$s_1^2 = 3742.49$ ($s_1 = 61.18$) $s_2^2 = 4716.14$ ($s_2 = 68.67$)	B1		B1 3742.49 (3740 ~ 3745) and 4716.14 (4710 ~ 4720)
	H_0: $\sigma_1 = \sigma_2$ H_1: $\sigma_1 \neq \sigma_2$	B1		B1 hypotheses correct
	$F = 4716.14/3742.49 = 1.26$	M1 A1		M1 method for F A1 1.26 (1.255 ~ 1.265) or 0.794 (0.793-0.794)
	c.v. $F_{[6,9]}$ is 4.32	B1 B1√		B1 6,9 df B1√ 4.32 - their df [Or 0.794 (0.793-0.794); 9,6df; 0.231]
	Accept H_0, no significant evidence that standard deviation has changed after October 2011	A1	7	A1 accept H_0 must be compared with F (or p = 0.7245 compared with 0.05)
(ii)	$\overline{x}_1 = 648.6$ $\overline{x}_2 = 619.86$	B1		B1 648.6 (648 ~ 649) and 619.86 (619.5 ~ 620)
	Pooled variance estimate $s_p^2 = (3742.49\text{x}9 + 4716.14\text{x}6)/15$ $= 4131.95$	M1		M1 method for pooled variance
	H_0: $\mu_1 = \mu_2$ H_1: $\mu_1 > \mu_2$	B1 B1		B1 one hypothesis correct B1 both hypotheses correct - don't penalise the same error twice
	$t = \dfrac{(648.6 - 619.86)}{\sqrt{4131.95(1/10 + 1/7)}}$ $= 0.907$	M1 M1 A1		M1 method for numerator M1 method for denominator - A1 0.907 (0.9 ~ 0.91) - ignore sign
	c.v. t_{15} is 1.753	B1 B1		B1 15 df B1 1.753 - ignore sign
	Accept H_0 i.e. no significant evidence of a reduction in Saturday takings after October 2011	A1√ A1√	11	A1√ accept H_0 - must be compared with correct tail of t A1√ conclusion in context 0 for contradiction (or p = 0.189 compared with 0.05)

Q	Solution	Marks	Total	Comments
4(b)(i)	H_0: $\mu_2 = \mu_1 + 50$ H_1: $\mu_2 > \mu_1 + 50$	B1 B1	2	B1 1 correct hypothesis B1 both correct - only penalise the same mistake once
(ii)	801,887,1013,884,964,1014,1146	M1 A1	2	M1 method A1 accuracy - allow one slip
(b)(iii)	critical value of t_{15} is 2.602 reject H_0, conclude total takings will be increased by more than £50.	B1 B1 B1	3	B1 2.602 B1 conclusion (M implied) B1 in context must be compared with t- values (or p=0.0000936)
(c)	There is no significant evidence that Saturday takings have been reduced and there is significant evidence that total weekend takings have increased by more than £50 per week. However the conclusions should be treated with caution because the samples of weekends are not random and in particular the takings after Sunday opening may be affected by the approach of Christmas. Sunday takings are increasing steadily - perhaps due to Christmas or customers getting used to Sunday opening.	E1 E1 E1 E1	4	E1 Saturday takings not reduced E1 no change in variability of Saturday takings E1 Total weekend takings increased more than £50 (maximum 2) E1 samples not random E1 may be affected by Christmas/familiarity
	Total		**29**	

Q	Solution	Marks	Total	Comments
5(a)(i)	$z_1 = (236.5 - 244.43)/4.09$ $= -1.939$ probability < 236.5 = 1 – 0.9737 = 0.0263 expected number in first class = 0.0263×105 = 2.76 expected number in last class 105 - 2.76 - 9.21 - 21.48 - 29.93 - 24.89 - 12.36 = 4.37 [or $z = (251.5 - 244.43)/4.09$ $= 1.729$ probability > 251.5 = 1 - 0.9581 = 0.0419 expected number in last class = 0.0419x105 = 4.40]	B1 B1 M1 m1 M1	 5	B1 attempt to find tail probability < B1 Use of 236.5 as upper bound of class or equivalent M1 method for probability not dependent on B marks - m1 their prob×105 M1 method for E last class
(ii)	Combining classes where E < 5 O E < 239 12 11.97 240 - 242 18 21.48 243 - 245 37 29.93 246 - 248 21 24.89 >248 17 16.73 H_0: Normal distribution is adequate model H_1: Normal distribution is not adequate model $\Sigma(O - E)^2/E = 0.03^2/11.97 + 3.48^2/21.48 + 7.07^2/29.93 + 3.89^2/24.89 + 0.27^2/16.73 = 2.85$ c.v. χ_2^2 is 4.605 No significant evidence that the normal distribution is not an adequate model for the temperature at which the lubricant becomes ineffective.	 M1 m1 M1 A1 B1√ B1 A1√ A1√	 8	 M1 attempt to combine classes m1 correct method for combining classes + correct classes combined M1 attempt at $\Sigma(O - E)^2/E$ - their Es A1 2.85 (2.8~2.9) needs previous M1m1M1 B1√ 2df B1 4.605 A1√ conclusion - needs all previous method marks; 5 marks for first (a)(i) and comparison with upper tail of χ^2 A1√ in context
(b)	Kabeera's claim is correct as this is a large sample. Mean will be approximately normally distributed whether the underlying distribution is normal or not. The sample will also give a good estimate of the standard deviation	 E1 E1	 2	 E1 claim correct E1 large sample/ central limit theorem
	Total		**15**	
	TOTAL		**75**	