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General Certificate of Education (A-level)
June 2012

Statistics SS04

(Specification 6380)

Statistics 4

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.

SS04

Q	Solution	Marks	Total	Comments
1	Approximate 95% confidence interval	B1		Use of $\sqrt{86}$ for s.d.
	$86 \pm 1.96\sqrt{86}$ 86 ± 18.18	M1 B1		Method for confidence interval, their s.d. 1.96
	$67.8 \sim 104.2$	A1	4	67.8 ($67.8 \sim 68$) and 104.2 ($104 \sim 104.2$) Allow in $\pm$ form
	Total		**4**	

Q	Solution	Marks	Total	Comments
2 (a)	$\overline{x} = 28.791$ $s = 2.4060$	B1		28.79 (28.75 ~ 28.85) and 2.406 (2.4 ~ 2.41)
	H_0: $\mu = 30.5$ H_1: $\mu \neq 30.5$	B1		Both hypotheses
	$t = \frac{(28.791\text{-}30.5)}{2.4060/\sqrt{11}}$	M1 m1		Use of their s.d./√11 Method for t - ignore sign
	$= -2.36$	A1		–2.36 (–2.35 ~ –2.36)
	c.v. t_{10} ± 2.228	B1 B1√		10df ± 2.228 their df - ignore sign
	Reject H_0 There is significant evidence that the mean length of male student's feet is less than (or not equal) 30.5cm.	A1√	8	Conclusion must be compared with lower tail of t and not inconsistent with their H_0. Allow arithmetic errors and incorrect t-values only
(b)	Assuming the sample is representative, there is evidence that the mean length of male student's feet is less than/not a foot. However the sample shows that some male students' feet will be greater than a foot (and some equal to a foot to some reasonable level of accuracy).	E1 E1	 2	Mean less than/not a foot - may be earned in (a) Some individuals greater or equal to a foot Allow a mark for other sensible comments eg only left feet measured - max 2
	Total		**10**	

Q	Solution	Marks	Total	Comments
3(a)	$p = 22/125 = 0.176$	B1		22/125 acf
	95% confidence interval for p	M1		Method for s.d.
	$0.176 \pm 1.96\sqrt{\dfrac{0.176 \times 0.824}{125}}$	B1 m1		1.96 Method – allow incorrect z-value
	0.176 ± 0.0668			
	$0.109 \sim 0.243$	A1	5	0.109 (0.109 ~ 0.11) and 0.243 (0.242~0.243) Allow in ± form
(b)	$p = 91/125 = 0.728$			
	95% confidence interval for p			
	$0.728 \pm 1.96\sqrt{\dfrac{0.728 \times 0.272}{125}}$	M1		Method – allow incorrect z- value
	0.728 ± 0.0780			
	$0.650 \sim 0.806$	A1	2	0.650 (0.645 ~ 0.655) and 0.806 (0.805~0.807) Allow in ± form
(c)(i)	No significant evidence of difference between USA and England for first statement since 0.21 lies between 0.109 and 0.243	B1√ E1√		No difference In interval
(ii)	No significant evidence of difference between USA and England for second statement since 0.66 lies between 0.650 and 0.806	B1		No difference
(iii)	Significant evidence that more agreed with second statement than first since confidence interval for agreement with second statement is wholly above that for first statement.	B1 E1	5	Evidence of difference No overlap of c.i.
	Total		**12**	

Q	Solution	Marks	Total	Comments
4(a)(i)	Binomial $n = 400$ $p = 0.0075$ $\rightarrow$ Poisson, mean $400\times0.0075 = 3$ P(>4) = 1 - 0.8153 = 0.185	M1 B1 A1	 3	Attempt at Poisson approx. mean 3 0.185 (0.18 ~ 19)
(ii)	Binomial $n = 400$ $p = 0.75$ $\rightarrow$ Normal, mean $400\times0.75 = 300$ s.d. = $\sqrt{}(400\text{x}0.75\times0.25) = 8.660$ $z_1 = (289.5 - 300)/8.660 = -1.212$ $z_2 = (305.5 - 300)/8.660 = 0.635$ P(≥290 and ≤305) = 0.7373 – (1 – 0.8874) = 0.625	 M1 m1 B1 M1 m1 A1	 6	 Attempt at normal approx. Method for mean and s.d./variance Attempt at continuity correction Method - ignore omitted or incorrect cc Completely correct method 0.625 (0.62 ~ 0.63)
(b)	both approximations give answers close to the exact answers.	E1√ E1	 2	Sensible comment - their answers Both good approximations
(c)(i)	Approximate confidence interval for proportions	E1	1	c.i. for proportions
(ii)	There is no practical use for Poisson approximation to binomial if you possess a calculator which will calculate all binomial probabilities exactly	E2(1)	2	Both marks for well expressed answer. Also allow credit for needed for exam/helps understanding of relationship between binomial and Poisson etc
	Total		**14**	

Q	Solution	Marks	Total	Comments
5(a)(i)	$z = (500 - 509)/4.5 = -2.0$	M1		Method – allow wrong tail
	probability bottle contains less than 500grams of beer is 1 – 0.97725			
	= 0.02275	A1		0.02275 (0.0225 ~ 0.023)
(ii)	P(not exactly 500) = 1	B1		cao
(iii)	distribution of $X + Y$ is normal mean 509 + 446 = 955	B1		955 cao
	s.d. $\sqrt{(4.5^2 + 5.6^2)} = 7.184$ (variance 51.61)	M1		Method for s.d./variance
	$z = (950 - 955)/7.184 = -0.696$	m1		Method – allow wrong tail
	probability bottle + beer weighs more than 950 grams = 0.757	A1	7	0.757 (0.754 ~0.76)
(b)(i)	normal, mean 955 - 446 = 509	B1		509 cao
	s.d. $\sqrt{(5.6^2 + 6.2^2)} = 8.355$ (variance 69.8)	M1	2	Method for s.d./variance
(ii)	$z = \dfrac{(500 - 509)}{8.355} = -1.077$	m1		Method allow wrong tail
	probability bottle contains less than 500grams of beer is 1 – 0.8594 = 0.141	A1	2	0.141 (0.14 ~ 0.143)
(c)	Amount of beer in bottle is more variable with new machine.	E2(1)	2	Amount of beer more variable. Allow a comparison of probabilities in (a)(i) and (b)(ii)
	Total		**13**	

Q	Solution	Marks	Total	Comments
6(a)	H_0: p = 0.45 H_1: p > 0.45	B1		Hypotheses
	B(15,0.45)	M1		Use of B(15,0.45)
	probability ≥ 9 = 1 - 0.8182 = 0.1818	A1		0.181 (0.181~0.182)
	0.1818 > 0.05 accept H_0: no significant evidence that Easter classes have improved pass rate	A1√ A1√	5	Conclusion In context
(b)	H_0: p = 0.45 H_1: p > 0.45	B1		Hypotheses
	B(48,0.45) → Normal mean 21.6 s.d. √(48×0.45×0.55) = 3.4467 (variance = 11.88)	B1 M1 m1		Use of B(48, 0.45) Attempt at normal approx. Method for mean and s.d./variance
	$z = \dfrac{(30.5 - 21.6)}{3.4467} = 2.58$	M1		Method for z – ignore sign and incorrect continuity correction
	$\left(\text{or } \dfrac{(31 - 21.6)}{3.4467} = 2.73\right)$	A1		2.58 (2.57~ 2.6) or 2.73 (2.7 ~ 2.75)
	c.v. 1.6449	B1		1.6449 (1.64~1.65) - ignore sign
	Reject H_0 Significant evidence that pass rates have improved following the Easter classes.	A1	8	conclusion - must be compared with correct tail of normal
(c)(i)	90% confidence interval for mean mark 55.75 ± 1.6449×9.81/√48	B1 M1		1.6449 or 1.678 (1.676~1.679) Method for c.i.
	55.75 ± 2.329 53.4 ~ 58.1	A1		53.4 (53.31 ~53.45) and 58.1 (58.05~58.15) Allow in ± form
(ii)	Since interval contains 54.2 there is no significant evidence that Easter holiday classes increases mean mark on this test	E1√ E1√	5	no evidence mean mark increased 54.2 in c.i.

Q	Solution	Marks	Total	Comments
6 cont (d)(i)	Significant evidence of increase in GCSE pass rate but not of increase in mean mark on practice examination.	E1√ E1	2	Their conclusion to (b) or (c) in context Correct conclusions to (b) and (c) stated in context
(ii)	The sample was self selecting and so not random. Probably consisting of better motivated students and/or parents so any observed improvements may be due to biased sample rather than the Easter classes.	E1 E1	2	Sample not random Possible reason
	Total		**22**	
	TOTAL		**75**	