OXFORD AQA
INTERNATIONAL QUALIFICATIONS

INTERNATIONAL A-LEVEL
FURTHER MATHEMATICS
FM7S2

Further Statistics 2

Mark scheme

Specimen

Version: 1.0

Mark schemes are prepared by the Lead Assessment Writer 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 associates 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 associate understands and applies it in the same correct way. As preparation for standardisation each associate 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, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Examiner.

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Key to mark scheme abbreviations

M	Mark is for method
m	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
ft	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
NMS	No method shown
PI	Possibly implied
sf	Significant figure(s)
dp	Decimal place(s)
ISW	Ignore subsequent working

Mark Scheme Alignment

Marks in the Marks column will typically align with the relevant line of mathematics in the Answer column where the mark is awarded. If two or more marks are awarded for the same line of mathematics, then the Guidance column will give further details as to how each mark is awarded.

Square Brackets

Where square brackets appear in a line of the mark scheme where one or more marks are awarded, the mathematics inside the square bracket is not required for marks to be awarded. Instead, they are intended to be helpful to users of the mark scheme.

Exceptions to this include integration, vectors and matrices where square brackets carry a different mathematical meaning.

Q	Answer	Marks	Guidance
1(a)	$z = 1.7507$	B1	**AWRT** 1.75
	$0.25 = 2 \times 1.7507 \times \frac{0.8}{\sqrt{n}}$	M1	Set up an equation with their $1.7507 \times \frac{0.8}{\sqrt{n}}$
	$n = 126$	A1	**CAO**
	Subtotal	3	

Q	Answer	Marks	Guidance
1(b)	$\overline{x}\left[= \frac{1260}{126} \right] = 10$	B1	Correct value for sample mean
	10 ± 0.125	M1	**ft** their $\overline{x}$
	$(9.875, 10.125)$	A1	**CAO**
	Subtotal	3	

	Question 1 Total	6	

Q	Answer	Marks	Guidance
2	$H_0 : \sigma_A^2 = \sigma_B^2$ $H_1 : \sigma_A^2 \neq \sigma_B^2$	**B1**	States both null and alternate hypotheses correctly **oe**
	$s_A^2 = \frac{128.4}{9-1} = 16.05, \quad s_B^2 = \frac{312.6}{13-1} = 26.05$	**M1**	Correct calculation for one of s_A^2 or s_B^2
	$F = \frac{s_B^2}{s_A^2} = \frac{26.05}{16.05} = 1.623$	**M1**	Calculates F test statistic with their values for s_A^2 and s_B^2
	$F = 1.623$	**A1**	**AWRT** 1.6
	$\nu_B = 12, \quad \nu_A = 8$	**M1**	**PI**
	$F_{12,8}(95\%) = 3.284$	**A1**	**AWRT** 3.3
	[0.351<] $1.623 < 3.284$ Fail to reject H_0	**A1ft**	Dependent on second **M** mark. Correct comparison of their F test statistic and their critical value. Critical value must be from the lower tail if $F < 1$ or from the upper tail if $F > 1$, or their p-value and 0.05, and concludes fail to reject H_0
	There is insufficient evidence [at the 10% significance level] to suggest that there is a difference in the population variance of volumes produced by the two models of pump.	**E1**	Gives a conclusion in context, by referring to the population variances of the two pumps, based on a comparison of the correct test statistic and correct critical value. Condone definite conclusion
	Question 2 Total	**8**	

Q	Answer	Marks	Guidance
3(a)(i)	$\mathrm{M}'_W(t) = (505 + 36t)\mathrm{e}^{505t+18t^2}$ $\mathrm{M}'_W(0) = (505 + 36\times 0)\mathrm{e}^{505\times 0+18\times 0}$ $\mathrm{E}(W) = 505$	**M1** **A1**	Differentiates $\mathrm{M}_W(t)$ to obtain the form $(p+qt)\mathrm{e}^{505t+18t^2}$ **AG** Must be convincingly shown
	Subtotal	**2**	

Q	Answer	Marks	Guidance
3(a)(ii)	$\mathrm{M}''_W(t) =$ $\left(36 + (505 + 36t)^2\right)\mathrm{e}^{505t+18t^2}$ $\mathrm{Var}(W) = \mathrm{M}''_W(0) - (\mathrm{M}'_W(0))^2$ $\mathrm{Var}(W) = (36 + 505^2) - (505)^2$ $\mathrm{Var}(W) = 36$	**M1** **M1** **A1**	Differentiates their $\mathrm{M}'_W(t) = (p+qt)\mathrm{e}^{505t+18t^2}$ to obtain the form $\mathrm{M}''_W(t) = \left(q + (p+qt)^2\right)\mathrm{e}^{505t+18t^2}$ Uses variance formula with their $\mathrm{M}'_W(0)$ and $\mathrm{M}''_W(0)$ **AG** Must be convincingly shown
	Subtotal	**3**	

Q	Answer	Marks	Guidance
3(b)(i)	$\mathrm{M}_X(t) = \mathrm{e}^{bt} \times \mathrm{e}^{505(at)+18(at)^2}$ $\mathrm{M}_X(t) = \mathrm{e}^{(505a+b)t+18a^2t^2}$	**M1** **A1**	Use of $\mathrm{M}_X(t) = \mathrm{e}^{bt} \times \mathrm{M}_W(at)$ **CAO**
	Subtotal	**2**	

Q	Answer	Marks	Guidance
3(b)(ii)	$\mathrm{E}(X) = 505a + b$ and $\mathrm{Var}(X) = 36a^2$	**B1**	Both required
	Subtotal	**1**	

	Question 3 Total	**8**	

Q	Answer	Marks	Guidance
4(a)	$H_0 : \sigma = 12$ $H_1 : \sigma \neq 12$	**B1**	Both hypotheses, **oe**
	$\chi^2 = \frac{(n-1)s^2}{\sigma^2} = \frac{50 \times 14.2^2}{12^2}$	**M1**	**PI** Condone not squaring 14.2 and 12
	$\chi^2 = 70$	**A1**	**AWRT** 70
	$\chi^2_{50}(95\%) = 67.505$ $\left[\chi^2_{50}(5\%) = 34.764\right]$	**B1**	**AWRT** 68 or correct probability, **AWRT** 0.97
	$70 > 67.5$ Reject H_0	**A1ft**	Correctly compares their χ^2 test statistic and their critical value, or their probability with 0.95, and makes the correct conclusion as to whether to reject the null hypothesis.
	There is sufficient evidence to suggest that the population standard deviation for the masses of the hamsters is not 12 grams [at the 10% level of significance]	**E1**	Gives a conclusion in context by referring to the population standard deviation of the masses of hamsters based on a comparison of the correct test statistic and correct critical value **oe** Condone definite conclusion
	Subtotal	**6**	

Q	Answer	Marks	Guidance
4(b)	$H_0 : \sigma_H^2 = \sigma_G^2$ $H_1 : \sigma_H^2 < \sigma_G^2$	**B1**	Both hypotheses, **oe** If different subscripts are used they must be defined.
	$F = \frac{s_G^2}{s_H^2} = \frac{272.25}{201.64}$	**M1**	**PI**
	$F = 1.35$	**A1**	**AWRT** 1.35
	$F_{40,50}(95\%) = 1.63$	**B1**	Finds correct critical value
	$1.35 < 1.63$ Fail to reject H_0	**A1ft**	Correctly compares their F test statistic and their critical value and makes the correct conclusion as to whether to reject the null hypothesis.
	Insufficient evidence to suggest that the population variance of the masses of the guinea pigs is greater than the population variance of the masses of the hamsters [at the 5% level of significance]	**E1**	Gives a conclusion in context by referring to the population variances of hamsters and guinea pigs based on a comparison of the correct test statistic and correct critical value **oe** Condone definite conclusion
	Subtotal	**6**	

	Question 4 Total	**12**	

Q	Answer	Marks	Guidance
5(a)	$X \sim \text{Po}(5)$		
	$\text{P}(X \leq 2) = 0.1247$ $[>0.05]$ $\text{P}(X \leq 1) = 0.0404$ $[<0.05]$	**M1**	Both probabilities seen
	$\text{P}(X \geq 9) = 0.0681$ $[>0.05]$ $\text{P}(X \geq 10) = 0.0318$ $[<0.05]$	**M1**	Both probabilities seen
	Acceptance Region: $2 \leq X \leq 9$	**A1**	**Pl** **oe**
	$Y \sim \text{Po}(7)$	**M1**	Uses $\text{Po}(7)$
	$\text{P}(\text{Type II error}) = \text{P}(2 \leq Y \leq 9)$		
	$\text{P}(\text{Type II error}) = \text{P}(Y \leq 9) - \text{P}(Y \leq 1)$	**m1**	**ft** their acceptance region
	$\text{P}(\text{Type II error}) = 0.8305 - 0.0073$		
	$[\text{P}(\text{Type II error}) =]$ 0.823	**A1**	**AWRT** 0.823
	Subtotal	**6**	

Q	Answer	Marks	Guidance
5(b)	$\text{Power} = 1 - 0.823$		
	$[\text{Power} =] 0.177$	**B1ft**	**ft** their $\text{P}(\text{Type II error})$
	Subtotal	**1**	

	Question 5 Total	**7**	

Q	Answer	Marks	Guidance
6(a)	$\mathrm{E}(\bar{X})\left[=\frac{1}{n}\times n\mu\right]=\mu$ $\mathrm{E}(\bar{Y})\left[=\frac{1}{m}\times m\mu\right]=\mu$ $\mathrm{E}(W)=\frac{n\mu+m\mu}{n+m}=\frac{(n+m)\mu}{n+m}$	M1	Both expectations equal to μ seen or used
	$\mathrm{E}(W)=\mu$	A1	Obtains $\mathrm{E}(W)=\mu$ with working seen
	Therefore, W is an unbiased estimator of μ	E1	Correct conclusion based on fully correct working
	Subtotal	**3**	

Q	Answer	Marks	Guidance
6(b)	$\mathrm{Var}(\bar{X})=\frac{\sigma^2}{n}$ and $\mathrm{Var}(\bar{Y})=\frac{\sigma^2}{m}$	M1	Both variances seen or used
	$\mathrm{Var}(W)=\left(\frac{n}{n+m}\right)^2\times\frac{\sigma^2}{n}+\left(\frac{m}{n+m}\right)^2\times\frac{\sigma^2}{m}$ $\mathrm{Var}(W)=\frac{(n+m)\sigma^2}{(n+m)^2}$		
	$\mathrm{Var}(W)=\frac{\sigma^2}{n+m}$	A1	**AG** Must be convincingly shown
	Subtotal	**2**	

Q	Answer	Marks	Guidance
6(c)	As $n+m \to \infty$, $\text{Var}(W) \to 0$ Therefore W is a consistent estimator of μ	M1 A1	oe Correct conclusion
	Subtotal	2	

	Question 6 Total	7	

Q	Answer	Marks	Guidance
7(a)(i)	$\overline{x} = \frac{406}{200} = 2.03$	M1	Correct mean
	$p = \frac{2.03}{5} = 0.406 = 0.4 \left[\text{to 1 dp}\right]$	A1	**AG** Must be convincingly shown
	Subtotal	**2**	

Q	Answer	Marks	Guidance
7(a)(ii)		B1	At least one value correct to 2 dp
		B1	Both values correct to 2 dp

Number of rare birds spotted	0	1	2	3	4	5
Expected frequency	15.55	51.84	69.12	46.08	15.36	2.05

	Subtotal	**2**	

Q	Answer	Marks	Guidance
7(b)	H_0 : The number of rare birds spotted follows a binomial distribution H_1 : The number of rare birds spotted does not follow a binomial distribution	**B1**	Both hypotheses Variable needs to be mentioned in at least H_0
	$\nu = 3$	**B1**	Correct degrees of freedom **PI**
	$\chi^2_3(95\%) = 7.815$	**B1**	**AWFW** [7.81, 7.82]
	As $2.05 < 5$, combine categories 4 and 5		
	$O = 24$, $E = 17.41$	**B1**	Correct values for combined observed frequency and combined expected frequency
	$\sum \frac{(O-E)^2}{E} = \frac{(18-15.55)^2}{15.55} + \frac{(52-51.84)^2}{51.84} + \frac{(65-69.12)^2}{69.12} + \frac{(41-46.08)^2}{46.08} + \frac{(24-17.41)^2}{17.41}$	**M1**	Attempt to calculate statistic
	$\left[\sum \frac{(O-E)^2}{E}\right] = 3.69$	**A1**	**AWRT** 3.7
	$3.686 < 7.815$ Fail to reject H_0	**A1ft**	Correctly compares their test statistic and their critical value and makes the correct conclusion as to whether to reject the null hypothesis.
	Insufficient evidence to suggest the binomial distribution is not a suitable model for the number of rare birds spotted [at the 5% level of significance]	**E1**	Gives a conclusion in context by referring to the number of rare birds spotted **oe** based on a comparison of the correct test statistic and the correct critical value Conclusion must not be definite, eg use of 'suggest', 'support'
	Subtotal	**8**	

	Question 7 Total	**12**	