OXFORD AQA
INTERNATIONAL QUALIFICATIONS

INTERNATIONAL AS/A-LEVEL
FURTHER MATHEMATICS
FM3S1

Further Statistics 1

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.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' 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 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)	$G_A(t) = 0.027 + 0.189t + 0.441t^2 + 0.343t^3$	M1	Expands $G_A(t)$
	$G'_A(t) = 0.189 + 0.882t + 1.029t^2$	A1	Obtains correct $G'_A(t)$ **oe**
	$G'_A(1) = 0.189 + 0.882 \times 1 + 1.029 \times 1^2$	M1	Attempts to find $G'_A(1)$
	$E(A)\ [= G'_A(1)] = 2.1$	A1	Finds correct value for $E(A)$ by finding $G'_A(1)$
	Subtotal	**4**	

Q	Answer	Marks	Guidance
1(b)	$G''_A(t) = 2.94(0.3 + 0.7t)$	M1	Differentiates $G'_A(t)$
	$G''_A(1) = 2.94$	A1	Obtains correct value **oe**
	$\text{Var}(A) = G''_A(1) + G'_A(1) - (G'_A(1))^2$		
	$\text{Var}(A) = 0.63$	A1	**CAO**
	Subtotal	**3**	

Q	Answer	Marks	Guidance
1(c)	$P(A = 2) = 0.441$	B1ft	**ft** their expanded $G_A(t)$
	Subtotal	**1**	

Q	Answer	Marks	Guidance
1(d)	[Maximum value =] 3	B1	**CAO**
	Subtotal	**1**	

	Question 1 Total	**9**	

Q	Answer	Marks	Guidance
2(a)	$X \sim \text{NB}(5, 0.2)$	B1	CAO
	Subtotal	1	

Q	Answer	Marks	Guidance
2(b)(i)	$\left[\text{E}(X) = \frac{r}{p} = \frac{5}{0.2} =\right]$ 25	B1	CAO
	Subtotal	1	

Q	Answer	Marks	Guidance
2(b)(ii)	$\text{Var}(X) = \frac{r(1-p)}{p^2} = \frac{5(1-0.2)}{0.2^2}$	M1	Substitutes their r and p from **part (a)** into the correct formula for the variance **PI**
	$\text{Var}(X) = 100$	A1	CAO
	Subtotal	2	

Q	Answer	Marks	Guidance
2(c)	On average 25 calls are received up to and including the 5th complaint.	E1	oe
	Subtotal	1	

	Answer	Marks	Guidance
2(d)	$\mathrm{P}(X = 10) = \binom{9}{4} \times 0.2^4 \times 0.8^5 \times 0.2$	**M1**	Calculation for 4 complaints in the first 9 calls followed by a complaint on the 10th call
	$\mathrm{P}(X = 10) = 0.0132$	**A1**	**AWRT** 0.0132
	Subtotal	**2**	

	Question 2 Total	**7**	

Q	Answer	Marks	Guidance
3(a)	$P(\text{pass}) = 0.8$	B1	States or uses the correct probability for emails that pass the check
	$P(\text{word}\mid\text{fail}) = 0.85$ $P(\text{word}\mid\text{pass}) = 0.12$	B1	States or uses the correct conditional probabilities
	$P(\text{word}) = P(\text{word}\mid\text{fail}) \times P(\text{fail}) + P(\text{word}\mid\text{pass}) \times P(\text{pass})$		
	$P(\text{word}) = 0.85 \times 0.2 + 0.12 \times 0.8$	M1	Substitutes their values into correct formula
	$P(\text{word}) = 0.266$	A1	Correct final probability for $P(\text{word})$
	$P(\text{pass}\mid\text{word}) = \dfrac{P(\text{word}\mid\text{pass}) \times P(\text{pass})}{P(\text{word})}$		
	$P(\text{pass}\mid\text{word}) = \dfrac{0.12 \times 0.8}{0.266} = 0.3609$	A1	**AWRT** 0.3609
	Subtotal	**5**	

Q	Answer	Marks	Guidance
3(b)	$P(\text{fail} \cap \text{word}) = P(\text{fail}) \times P(\text{word} \mid \text{fail})$		
	$P(\text{fail} \cap \text{word}) = 0.2 \times 0.85$	M1	Attempt to find that the email fails the check and contains a particular word **PI**
	$P(\text{fail} \cap \text{word}) = 0.17$		
	$P(\text{pass} \cap \text{no word})$ $= P(\text{pass}) \times P(\text{no word} \mid \text{pass})$		
	$P(\text{pass} \cap \text{no word}) = 0.8 \times 0.88$	M1	Attempt to find that the email passes the check and does not contain a particular word **PI**
	$P(\text{pass} \cap \text{no word}) = 0.704$		
	$P(\text{works correctly}) = 0.17 + 0.704$		
	$P(\text{works correctly}) = 0.874$	A1	**AWRT** 0.874
	Subtotal	**3**	

	Question 3 Total	**8**	

Q	Answer	Marks	Guidance
4(a)(i)	$\mathrm{E}(J)=\frac{n+1}{2}=\frac{10+1}{2}$	**M1**	Substitutes 10 into correct formula **PI**
	$\mathrm{E}(J)=5.5$	**A1**	**CAO**
	Subtotal	**2**	

Q	Answer	Marks	Guidance
4(a)(ii)	$\mathrm{Var}(J)=\frac{10^2-1}{12}$	**M1**	Substitutes 10 into correct formula **PI**
	$\mathrm{Var}(J)=8.25$	**A1**	**CAO**
	Subtotal	**2**	

Q	Answer	Marks	Guidance
4(a)(iii)	$\mathrm{P}(J>7)=\mathrm{P}(J=8)+\mathrm{P}(J=9)$ $+\mathrm{P}(J=10)$	**M1**	Identifies correct outcomes **PI**
	$\mathrm{P}(J>7)=0.3$	**A1**	**CAO**
	Subtotal	**2**	

Q	Answer	Marks	Guidance
4(b)(i)	$(1-p)\,p = 0.16$	**M1**	Forms correct equation. May be in the form $qp = 0.16$
	$p^2 - p + 0.16 = 0$		
	$p = 0.2,\ 0.8$	**A1**	Finds both values for p
	Since $p < 0.45 \Rightarrow p = 0.2$	**M1**	Selects correct value **PI**
	$\text{Var}(K) = \dfrac{1-p}{p^2}$		
	$\text{Var}(K) = \dfrac{1-0.2}{0.2^2}$		
	$\text{Var}(K) = 20$	**A1**	**CAO**
	Subtotal	**4**	

Q	Answer	Marks	Guidance
4(b)(ii)	If J and K are independent, then $\text{Var}(J-4K) = \text{Var}(J) + (-4)^2\,\text{Var}(K)$		
	$= 8.25 + 16 \times 20$	**M1**	Substitutes their value of $\text{Var}(J)$ and $\text{Var}(K)$ into $\text{Var}(J) + (-4)^2\,\text{Var}(K)$
	$= \dfrac{1313}{4}$	**A1ft**	**oe**, such as 328.25 **ft** their values from **part (a)(ii)** and **part (b)(i)**
	As $\text{Var}(J-4K) = 328$ $\neq \dfrac{1313}{4} = \text{Var}(J) + (-4)^2\,\text{Var}(K)$ then J and K are not independent	**E1**	Correct conclusion with justification
	Subtotal	**3**	

	Question 4 Total	**13**	

<table>
<tr><th>Q</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>5(a)(i)</td><td>
<table>
<tr><th>Time rank</th><th>Mark rank</th><th>d_i</th><th>d_i^2</th></tr>
<tr><td>2</td><td>4</td><td>–2</td><td>4</td></tr>
<tr><td>6</td><td>6</td><td>0</td><td>0</td></tr>
<tr><td>1</td><td>1</td><td>0</td><td>0</td></tr>
<tr><td>5</td><td>5</td><td>0</td><td>0</td></tr>
<tr><td>8</td><td>8</td><td>0</td><td>0</td></tr>
<tr><td>4</td><td>3</td><td>1</td><td>1</td></tr>
<tr><td>3</td><td>2</td><td>1</td><td>1</td></tr>
<tr><td>7</td><td>7</td><td>0</td><td>0</td></tr>
</table>

$\sum d_i^2 = 6$

$r_s = 1 - \frac{6\sum d_i^2}{n\left(n^2-1\right)} = 1 - \frac{6\times 6}{8\left(8^2-1\right)}$

$r_s = 0.929$
</td><td>M1

A1

M1

A1</td><td>Ranks times and marks
Allow one error
PI

Obtains the correct value for sum of differences squared
PI

Use of correct formula with their value of $\sum d_i^2$ substituted correctly
PI

AWRT 0.929</td></tr>
<tr><td></td><td>Subtotal</td><td>4</td><td></td></tr>
</table>

Q	Answer	Marks	Guidance
5(a)(ii)	$H_0 : \rho_s = 0$ $H_1 : \rho_s > 0$	**B1**	Sets up hypotheses correctly
	Critical value = 0.6429	**M1**	Finds correct critical value
	As $0.929 > 0.6429$ Reject H_0	**A1ft**	Correctly compares their test statistic with the correct critical value and makes the correct conclusion as to whether to reject the null hypothesis
	There is evidence to suggest that there is positive association between the time in hours a student revises each week and their mark on an exam [at the 5% level of significance]	**E1ft**	Gives a conclusion in context by referring to the time in hours a student revises each week and their mark on an exam based on a comparison of their test statistic and 0.6429 **oe** Conclusion must not be definite, eg use of 'suggest', 'support'
	Subtotal	**4**	

Q	Answer	Marks	Guidance
5(b)	The values of the variables can be ranked	**E1**	**oe**
	Any association between the two variables is monotonic	**E1**	**oe**
	Subtotal	**2**	

	Question 5 Total	**10**	

Q	Answer	Marks	Guidance
6(a)(i)	$\mathrm{E}(T)=\mathrm{E}(X+Y)=\mathrm{E}(X)+\mathrm{E}(Y)$ $\mathrm{E}(T)=1.1+1.2$ $\mathrm{E}(T)=2.3$	 M1 A1	 Substitutes values into correct equation **PI** **CAO**
	Subtotal	**2**	

Q	Answer	Marks	Guidance
6(a)(ii)	$\mathrm{Var}(T)=(1)^2\,\mathrm{Var}(X)+(1)^2\,\mathrm{Var}(Y)$ $\mathrm{Var}(T)=0.89+1.36$ $\mathrm{Var}(T)=2.25$	 M1 A1	 Substitutes values into correct equation **PI** **CAO**
	Subtotal	**2**	

Q	Answer	Marks	Guidance
6(b)(i)	$x+y=3$		
	(0,3), (1,2), (2,1) and (3,0)	**M1**	Attempt to find contributing pairs **PI**
	$\mathrm{P}(T=3)=0.3\times0.2+0.4\times0.2$ $+0.2\times0.2+0.1\times0.4$	**M1**	Use of independence to form probability expression
	$\mathrm{P}(T=3)=0.22$	**A1**	**CAO**
	Subtotal	**3**	

Q	Answer	Marks	Guidance
6(b)(ii)	$\mathrm{P}(T>3\|Y=2)=\dfrac{0.2\times0.2+0.2\times0.1}{0.2}$	**M1**	**oe**
	$\mathrm{P}(T>3\|Y=2)=0.3$	**A1**	**CAO**
	Subtotal	**2**	

Q	Answer	Marks	Guidance
6(c)(i)	$\text{Cov}(X,Y) = \rho\sqrt{\text{Var}(X)\text{Var}(Y)}$		
	$\text{Cov}(X,Y) = 0.25\sqrt{0.89\times 1.36}$	M1	Substitutes values into correct formula
	$\text{Cov}(X,Y) = 0.275$	A1	**AWRT** 0.275
	Subtotal	**2**	

Q	Answer	Marks	Guidance
6(c)(ii)	$\text{Var}(T) = \text{Var}(X) + \text{Var}(Y) + 2\text{Cov}(X,Y)$		
	$\text{Var}(T) = 0.89 + 1.36 + 2\times 0.275$	M1	Substitutes values into correct formula
	$\text{Var}(T) = 2.8$	A1	**AWRT** 2.8
	Subtotal	**2**	

	Question 6 Total	**13**	