Mark Scheme (Results)

Summer 2022

Pearson Edexcel GCE
In Further Mathematics (8FM0)
Paper 24 Further Statistics 2

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Summer 2022
Question Paper Log Number P71968A*
Publications Code 8FM0_24_2206_MS*
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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

EDEXCEL GCE MATHEMATICS
General Instructions for Marking

1. The total number of marks for the paper is 40.

2. The Edexcel Mathematics mark schemes use the following types of marks:

- **M** marks: method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
- **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
- **B** marks are unconditional accuracy marks (independent of M marks)
- Marks should not be subdivided.

3. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes.

- bod – benefit of doubt
- ft – follow through
- the symbol $\surd$ will be used for correct ft
- cao – correct answer only
- cso - correct solution only. There must be no errors in this part of the question to obtain this mark
- isw – ignore subsequent working
- awrt – answers which round to
- SC: special case
- oe – or equivalent (and appropriate)
- dep – dependent
- indep – independent
- dp decimal places
- sf significant figures
- $*$ The answer is printed on the paper
- ⌐ The second mark is dependent on gaining the first mark

4. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected.

5. Where a candidate has made multiple responses and indicates which response they wish to submit, examiners should mark this response.
   If there are several attempts at a question which have not been crossed out, examiners should mark the final answer which is the answer that is the most complete.

6. Ignore wrong working or incorrect statements following a correct answer.

7. Mark schemes will firstly show the solution judged to be the most common response expected from candidates. Where appropriate, alternatives answers are provided in the notes. If examiners are not sure if an answer is acceptable, they will check the mark scheme to see if an alternative answer is given for the method used.

Question	Scheme	Marks	AOs
1(a)	$\left[r_s = 1 - \frac{6\times 84}{10(10^2-1)}\right]$ $= 0.4909...$ awrt **0.491**	B1	1.1b
		(1)	
(b)(i) (ii)	$(1>)r_s > 0.5636$	B1	1.1b
	(0.491 is not in the critical region) There is insufficient evidence of agreement between their film ranks.	B1ft	2.2b
		(2)	
(c)	new $r_s = 1 - \frac{6\times 84}{11(11^2-1)}$	M1	1.1b
	$= 0.61818...$ awrt **0.618**	A1	1.1b
	new critical value is 0.5364	B1	1.1b
	There is now sufficient evidence of agreement between their film ranks.	A1	2.2b
		(4)	
			(7 marks)

Notes	
(a)	**B1:** awrt 0.491 (allow $\frac{27}{55}$)
(b)(i) **(ii)**	**B1:** Correct critical region with 0.5636 or better. Condone use of ρ instead of r_s **B1ft:** Correct ft contextualised conclusion (must include film or ranks) based on their (a) and their CR Allow ft on their CV if a CR is not stated
(c)	**M1:** Use of formula with same $\sum d^2$ and 11 **A1:** awrt 0.618 (allow $\frac{34}{55}$) **B1:** 0.5364 or better **A1:** fully correct solution with awrt 0.618 and contextualised conclusion (must include film or ranks)

<table>
<tr><th>Question</th><th colspan="3">Scheme</th><th>Marks</th><th>AOs</th></tr>
<tr><td rowspan="3">2(a)</td><td colspan="3">$\mathrm{P}(X<4)=\dfrac{(4-1)\times 0.1}{2}$ or $\int_1^4 \frac{1}{30}(x-1)\mathrm{d}x$</td><td>M1</td><td>2.1</td></tr>
<tr><td colspan="3">$=0.15$</td><td>A1</td><td>1.1b</td></tr>
<tr><td colspan="3"></td><td>(2)</td><td></td></tr>
<tr><td rowspan="3">(b)</td><td>$\dfrac{(7-1)\times 0.2}{2}+\ldots$
$\ldots 0.1(x-7)$</td><td>$\int_1^7 \frac{1}{30}(x-1)\mathrm{d}x+\ldots$
$\ldots \int_7^x 0.1\mathrm{d}t$</td><td>$\int 0.1\mathrm{d}x$
$\mathrm{F}(7)=0.1x+c$
or
$\mathrm{F}(11)=0.1x+c$</td><td>M1
M1</td><td>3.1a
1.1b</td></tr>
<tr><td colspan="3">$\mathrm{F}(x)=0.1x-0.1 \quad [\text{for } 7\le x\le 11]$</td><td>A1</td><td>1.1b</td></tr>
<tr><td colspan="3"></td><td>(3)</td><td></td></tr>
<tr><td colspan="5"></td><td>(5 marks)</td></tr>
<tr><td colspan="6">Notes</td></tr>
<tr><td>(a)</td><td colspan="5">M1: Use of area of triangle or integration with limits to find required area
Condone $\dfrac{4\times 0.1}{2}$ or $\int_1^4 \frac{1}{30}(x)\mathrm{d}x$ for M1
A1: 0.15 oe</td></tr>
<tr><td>(b)</td><td colspan="5">M1: Complete method for finding the cdf including area from $1\le x<7$
Condone one slip for the area from $1\le x<7$
M1: Attempt at area from $7\le x\le 11$
A1: $0.1x-0.1$</td></tr>
</table>

Question	Scheme	Marks	AOs
3(a)	$S_{ww} = 11\,386\,134 - 27(628.59)^2 [= 717\,748.5213]$	B1	1.1b
	$r = \dfrac{13\,082.3}{\sqrt{260.8 \times '717\,748.5213'}}$	M1	1.1b
	$r = 0.95618....$ awrt **0.956**	A1	1.1b
		(3)	
(b)	Since r is close to 1, data is consistent with a linear model.	B1	2.4
		(1)	
(c)	$b = \dfrac{13\,082.3}{260.8} [= 50.162...]$	M1	3.3
	$a = 628.59 - 'b'(31.07)$	M1	1.1b
	$w = -930 + 50.2x$	A1	1.1b
		(3)	
(d)	$w = -930 + 50.2(32) + 80$	M1	3.4
	$w = 756.4$	A1	1.1b
		(2)	
(e)	Negative residuals for all 5 observations with $x > 33$ suggests the model systematically overestimates weights for the longest bream.	B1	3.5a
		(1)	
			(10 marks)

Notes

(a)	**B1:** Correct expression for S_{ww} (implied by a correct answer) **M1:** Complete method to find r (Use of S_{ww} = 11 386 134 is M0) **A1:** awrt 0.956
(b)	**B1:** Correct explanation and conclusion
(c)	**M1:** Setting up linear model by finding gradient **M1:** Attempting y-intercept of linear model **A1:** Correct model with b = awrt 50.2 and a = awrt –930 (must use w and x)
(d)	**M1:** Using the model with the residual. Allow $\pm$ 80 **A1:** awrt 756 (allow awrt 755 from use of exact values)
(e)	**B1:** Evaluating the model for $x > 33$ (must reference both the residuals and the model) Negative correlation between residuals and length is B0.

Question	Scheme	Marks	AOs
4(a)	$\int_2^m (0.8-6.4x^{-3})\mathrm{d}x = 0.5$	M1	2.1
	$\left[0.8x+3.2x^{-2}\right]_2^m = 0.5$	M1	1.1b
	$0.8m+\frac{3.2}{m^2}-\left(0.8(2)+\frac{3.2}{2^2}\right)=0.5 \rightarrow 0.8m+\frac{3.2}{m^2}-2.9=0 \rightarrow$ $m^3-3.625m^2+4=0$ *	A1*cso	1.1b
		(3)	
(b)(i) (ii)	$f'(x)=19.2x^{-4}$	B1	1.1b
	Since $f'(x)>0, f(x)$ is increasing (the pdf has its maximum value at the upper end of the interval), the mode is 4	B1	2.4
		(2)	
(c)	$E(X)=\int_2^4 x(0.8-6.4x^{-3})\mathrm{d}x$	M1	1.1b
	$E(X)=\left[0.4x^2+6.4x^{-1}\right]_2^4$ $=0.4(4^2)+6.4(4^{-1})-\left(0.4(2^2)+6.4(2^{-1})\right)[=3.2]$	M1	1.1b
	$\mathrm{Var}(X)=10.5-'3.2'^2$	M1	1.1b
	$\mathrm{Var}(X)=0.26$	A1	1.1b
		(4)	
			(9 marks)

Notes	
(a)	**M1:** Integral = 0.5 (ignore limits) **M1:** Integration with limits **A1*cso:** Given answer with at least one line of intermediate working.
(b)(i) (ii)	**B1:** $19.2x^{-4}$ **B1:** Correct reasoning and conclusion (allow equivalent correct reasoning e.g. no turning points with a sketch of f(x)). Do not allow unsupported comments on their own to score e.g. 'x = 4 is the highest point on f(x)'
(c)	**M1:** Multiplying out xf(x) and attempt to integrate **M1:** correct use of limits (implied by 3.2oe) **M1:** Use of $E(X^2)-[E(X)]^2$ **A1:** 0.26

Question	Scheme	Marks	AOs
5(a)	$\left[\mathrm{P}(T<1)=\dfrac{1-0.5}{2.5-0.5}\right]=\dfrac{1}{4}$	B1	3.4
		(1)	
(b)	$\mathrm{P}\left(\{T<2.25\}\cap\left\{\dfrac{1}{T^2}<2.25\right\}\right)=\mathrm{P}\left(\{T<2.25\}\cap\left\{T^2>\frac{4}{9}\right\}\right)$	M1	2.1
	$\mathrm{P}\left(\frac{2}{3}<T<2.25\right)=\dfrac{2.25-\frac{2}{3}}{2.5-0.5}$	M1	1.1b
	$=\dfrac{19}{24}$	A1	1.1b
		(3)	
(c)	$\mathrm{E}(R)=1.5$	B1	1.1b
	$\mathrm{E}\left(\dfrac{2}{R^2}\right)=\displaystyle\int_{0.5}^{2.5}\left(\dfrac{1}{2.5-0.5}\right)\dfrac{2}{r^2}\ \mathrm{d}r$	M1	3.1b
	$\left[-\dfrac{1}{r}\right]_{0.5}^{2.5}$	dM1	1.1b
	=1.6	A1	1.1b
	Greta is the expected winner since she has the higher expected value (1.6 > 1.5)	A1	2.2b
		(5)	
			(9 marks)
	Notes		
(a)	**B1:** 0.25 oe		
(b)	**M1:** Determining the conditions for both numbers to be smaller than 2.25 **M1:** Use of uniform distribution for their region for T **A1:** allow awrt 0.792		
(c)	**B1:** 1.5 **M1:** Attempt to set up an integral for Greta's expectation **dM1:** (dep on previous M1) for integration of expectation **A1:** 1.6 **A1:** Greta with correct supporting reason and all previous marks scored in (c) **SC:** Use of $R=\dfrac{2}{R^2}\rightarrow R=\sqrt[3]{2}\rightarrow 1.5>\sqrt[3]{2}(=1.25...)$ therefore Raja is more likely to win a single game, scores B1M0M0A0A1.		

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