Mark Scheme (Results)

Summer 2024

Pearson Edexcel GCE Further Mathematics
Advanced Subsidiary Level
in Further Statistics 2 Paper 8FM0_24

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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)	$\frac{d}{dx}[\frac{1}{5}(x+1)^2]=\frac{2}{5}(x+1)$ or $\frac{d}{dx}[1-\frac{1}{20}(4-x)^2]=\frac{1}{10}(4-x)$	M1	2.1
	$f(x)=\begin{cases}\frac{2}{5}(x+1) & -1,, x,, 0\\ \frac{1}{10}(4-x) & 0<x,, 4\\ 0 & \text{otherwise}\end{cases}$	A1	1.1b
		(2)	
(b)(i)	Shape: Triangle with longer slant in 1st quadrant	B1	1.1b
	Labels: –1, 4 on horizontal axis and $\frac{2}{5}$ on vertical axis	B1	1.1b
		(2)	
(ii)	(Probability density function has a longer tail to right,) so there is **positive skew**.	dB1	2.4
		(1)	
(c)	P(1 < X < 2) = F(2) – F(1) or 2F(c) = F(2) + F(1)		
	$=\left(1-\frac{4}{20}\right)-\left(1-\frac{9}{20}\right)=\frac{5}{20}$ or $\frac{1}{4}$ or stating F(c) = 0.675	M1	3.1a
	So e.g. $P(c<X<2)=\frac{1}{8} \Rightarrow \frac{1}{8}=\frac{(4-c)^2}{20}-\frac{4}{20}$	M1	1.1b
	$c=\frac{8-\sqrt{26}}{2}$ or 1.45049… awrt **1.45**	A1	1.1b
		(3)	
			(8 marks)

Notes	
(a)	**M1:** Attempt to differentiate 2nd line of cdf in the form $k(x + 1)$ (oe) or 3rd line of cdf in the form $m(4 – x)$ (oe) **A1:** Correct probability density function. (Condone missing "0 otherwise" and mis-use of < or ,, etc)
(b)(i) **(ii)**	**1st B1:** Correct shape. Triangle must have both ends on axis **2nd B1:** Correct labels. All three needed. **dB1:** Correct description of positive skew. **Dep** on sketch that clearly shows positive skew.
(c)	**1st M1:** Suitable start to problem e.g. showing P(1 < X < 2) = 0.25 o.e. e.g. F(c) = 0.675 or 2F(c) = 0.8 + 0.55 **2nd M1:** Rearranging to form quadratic equation in c can ft their "0.25" e.g. $2c^2-16c+19=0$ Allow even if wrong part of F(x) is used so M0M1A0 is possible. **A1:** for awrt 1.45 only NB Other root is 6.549… and if this is not rejected score A0

Question	Scheme	Marks	AOs
2	$H_0 : \rho_s = 0 \quad H_1 : \rho_s < 0$	B1	2.5
	<table><tr><td>x</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td></tr><tr><td>y</td><td>7</td><td>8</td><td>5</td><td>6</td><td>3</td><td>4</td><td>2</td><td>1</td></tr><tr><td>d^2</td><td>36</td><td>36</td><td>4</td><td>4</td><td>4</td><td>4</td><td>25</td><td>49</td></tr></table> $\sum d^2 = 162$	M1 dM1	3.1a 1.1b
	$r_s = 1 - \dfrac{6\times "their \sum d^2"}{8(8^2-1)}$	M1	1.1b
	$r_s = -0.9285...$ awrt **–0.929**	A1	1.1b
	Critical value –0.8333	B1	1.1b
	(Reject H_0) there is sufficient evidence to suggest the data shows negative rank correlation.	A1ft	2.2b
		(7)	
			(7 marks)

Notes

1st B1: Both hypotheses correct in terms of ρ_s or ρ

1st M1: for an attempt to rank both rows (at least 4 correct in one row or 2 pairs). Condone reverse rankings.

<table><tr><td>x</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td></tr><tr><td>y</td><td>2</td><td>1</td><td>4</td><td>3</td><td>6</td><td>5</td><td>7</td><td>8</td></tr><tr><td>d^2</td><td>1</td><td>1</td><td>1</td><td>1</td><td>1</td><td>1</td><td>0</td><td>0</td></tr></table>

$\sum d^2 = 6$

2nd dM1: dep on 1st M1 for attempt at d or d^2 row for their rankings.

3rd M1: for use of $1 - \dfrac{6\times "162"}{8(8^2-1)}$ Allow independently of 1st M1 and 2nd M1

1st A1: awrt –0.929 allow $-\dfrac{13}{14}$ or – 0.928 following a correct expression

Allow for + 0.929 etc following correct reverse ranking using $\sum d^2 = 6$

2nd B1: correct critical value (allow $\pm$ 0.8333). 4dp here but allow 3 in 2nd A1

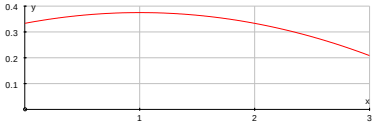
2nd A1ft: dependent upon all M marks and $|r_s| = 0.929$ **or** |cv| = 0.833(or better)

No incorrect statements e.g. "accept H_0 there is evidence of negative …"

If comparison is seen it must be correct:

e.g. – 0.929 > – 0.833 or – 0.929 < 0.833 are both A0

Allow "insufficient evidence of negative rank correlation" provided it follows from their r_s and their cv (at least one of which must be correct).

Question	Scheme	Marks	AOs
3(a)	Sketch or differentiation to find mode of Y  $f'(y) = \frac{1}{24}(2-2y) = 0$	M1	3.1a
	Mode occurs at $Y = 1$ *	A1*	1.1b
		(2)	
(b)	By symmetry $P(Y < 2) = 2\times\frac{13}{36} = \frac{13}{18}$ (or 0.72 or better)	M1	2.1
	Median is less than 2 since $\frac{13}{18} > \frac{1}{2}$	A1	2.4
		(2)	
(c)	$E(Y) = \int_0^3 \frac{1}{24} y(y+2)(4-y)\ dy$ or $\int_0^3 \frac{1}{24}\left(8y+2y^2-y^3\right)\ dy$	M1	1.1b
	$E(Y) = \frac{1}{24}\left[4y^2+\frac{2}{3}y^3-\frac{y^4}{4}\right]_0^3 \rightarrow \frac{1}{24}\left[\left(36+18-\frac{81}{4}\right)-(0)\right] \left[=\frac{45}{32}\right]$	M1	1.1b
	$\text{Var}(Y) = E(Y^2)-[E(Y)]^2 = \frac{213}{80} - \left("\frac{45}{32}"\right)^2 \left[=\frac{3507}{5120}\right]$	M1	1.1b
	$\text{Var}(2Y) = 4\text{Var}(Y)$	M1	3.1a
	$= \frac{3507}{1280}$ =2.73984… awrt **2.74**	A1	1.1b
		(5)	
			(9 marks)

Notes

(a)	**M1:** Attempt to find the mode e.g. diff'n, complete the square or sketch in (a) **A1*:** fully correct justification, must show or explain why a max e.g. reference to negative quadratic (and 1 is in [0,3]). Allow "decreasing function"
(b) **ALT**	**M1:** use of symmetry or other method e.g. calculator to determine $P(Y < 2)$ **A1:** for median is less than 2 with correct reasoning **M1** for attempt at $F(y) = \frac{1}{24}\left(-\frac{y^3}{3}+y^2+8y\right)$ **and** $F(y) = \frac{1}{2}$ Condone missing $\frac{1}{24}$ for M1 **A1** for awrt 1.37 and comment with some evidence that $F(y) = \frac{1}{2}$ attempted
(c)	**1st M1:** Attempt to integrate $yf(y)$ – ignore limits here. | **Must see algebraic** Need to see at least one $y^n \rightarrow y^{n+1}$ | **integration for 1st** **2nd M1:** Substitution of correct limits into integral of $yf(y)$ | **and 2nd M1** Don't need to see limits used if intention is clear and answer correct. **3rd M1:** Attempt to find variance i.e. use of $E(Y^2) - [E(Y)]^2$ ft their $E(Y)$ **4th M1:** Use of $\text{Var}(2Y) = 2^2\text{Var}(Y)$. Independent of 1st ~ 3rd M1 **A1: (dep on all Ms)** for $\frac{3507}{1280}$ or awrt 2.74

Question	Scheme	Marks	AOs
4(a)	$\mathrm{E}(X) = \underline{\mathbf{4.5}}$	B1	1.1b
		(1)	
(b)	$\left[\mathrm{P}(1 < X < 4) = \mathrm{P}(2 < X < 4) =\right] \frac{2}{5}$	B1	1.1b
		(1)	
(c)	$2X^2 - 15X + 27 > 0 \rightarrow \left[\{X < 3\} \cup \{X > 4.5\}\right]$	M1	3.1a
	$\mathrm{P}(\{X < 3\} \cup \{X > 4.5\}) = \frac{3-2}{7-2} + \frac{7-4.5}{7-2}\left[= 1 - \frac{4.5-3}{7-2}\right]$	M1	1.1b
	$= \frac{7}{10}$ or $\underline{\mathbf{0.7}}$	A1	1.1b
		(3)	
(d)	$\mathrm{E}\left(\frac{3}{X^2}\right) = \int_2^7 \frac{3}{x^2} \times \frac{1}{(7-2)} \mathrm{d}x$	M1	3.1a
	$= \left[-0.6x^{-1}\right]_2^7$	M1	1.1b
	$= \frac{3}{14}$	A1	1.1b
		(3)	
			(8 marks)

Notes	
(a)	**B1:** 4.5 oe
(b)	**B1:** $\frac{2}{5}$ oe
(c)	**1st M1:** Attempting to find roots. Can be implied by sight or use of 3 and 4.5 **2nd M1:** Attempt to find probability for their "outside" region from U[2, 7] Must have both correct ft probability statements and at least one correct ft probability e.g. P(X < 3) = 0.2 and P(X > 4.5) = 0.5 followed by 0.2×0.5 is M0M1A0 **A1:** $\frac{7}{10}$ oe
(d)	**1st M1:** use of E(g(x)) by setting up correct integral (ignore limits) **2nd M1:** integration with limits **A1:** $\frac{3}{14}$ oe from correct working

Question	Scheme	Marks	AOs
5(a)	$S_{ss} = \frac{S_{sh}}{b} = \frac{0.352}{0.919} [= 0.383...]$ or $\frac{352}{919}$	M1	2.1
	$r = \frac{0.352}{\sqrt{0.377 \times "0.383"}}$	M1	1.1b
	$r = 0.9263\ldots$ awrt **0.926**	A1	1.1b
		(3)	
(b)	$h - 1.68 = 0.919(1.79 - 1.70)$	M1	3.4
	$h = 1.76271$ awrt **1.76**	A1	1.1b
		(2)	
(c)	S_{ss} would remain the same since $s_{25} = \bar{s}$	M1	2.4
	S_{sh} would remain the same additional $(s - \bar{s})(h - \bar{h}) = 0$	M1	1.1b
	So the gradient would be unchanged.	A1	2.2a
		(3)	
			(8 marks)

Notes

(a)

1st M1: realising the need to find S_{ss} Must have $0.919 = \frac{0.352}{S_{ss}}$ or better

2nd M1: attempt to find r ft their S_{ss} provided $S_{ss} > 0.33$

A1: awrt 0.926

(b)

M1: using model with means and 1.79 to find h. May see: $0.1177 + 0.919 \times 1.79$
Allow $0.1177 + 0.919 \times 1.75$ as MR

A1: awrt 1.76

(c)

1st M1: explaining the effect on S_{ss}

2nd M1: considering the effect on S_{sh}

A1: correct deduction

ALT

1st M1 explaining that $s_{25} = \bar{s}$ so point lies on $s = \bar{s}$ Must be explicit

2nd M1 $h_{25} > \bar{h}$ so the line would move upwards (parallel to original regression line)

A1 correct deduction

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