



# Mark Scheme (Results)

Summer 2024

Pearson Edexcel GCE Further Mathematics  
Advanced Subsidiary Level  
in Further Statistics 2 Paper 8FM0\_24

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Summer 2024

Question Paper Log number 75674

Publications Code 8FM0\_24\_2406\_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.

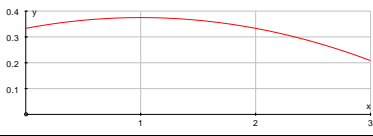
### 3. Abbreviations

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
  - $\square$  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
<b>1(a)</b>	$\frac{d}{dx}[\frac{1}{5}(x+1)^2] = \frac{2}{5}(x+1)$ or $\frac{d}{dx}[1 - \frac{1}{20}(4-x)^2] = \frac{1}{10}(4-x)$	M1	2.1
	$f(x) = \begin{cases} \frac{2}{5}(x+1) & -1 \leq x \leq 0 \\ \frac{1}{10}(4-x) & 0 < x \leq 4 \\ 0 & \text{otherwise} \end{cases}$	A1	1.1b
		<b>(2)</b>	
<b>(b)(i)</b>	Shape: Triangle with longer slant in 1 <sup>st</sup> quadrant	B1	1.1b
	Labels: -1, 4 on horizontal axis and $\frac{2}{5}$ on vertical axis	B1	1.1b
		<b>(2)</b>	
<b>(ii)</b>	(Probability density function has a longer tail to right,) so there is <b>positive skew</b> .	dB1	2.4
		<b>(1)</b>	
<b>(c)</b>	$P(1 < X < 2) = F(2) - F(1)$ 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 <b><u>1.45</u></b>	A1	1.1b
		<b>(3)</b>	
<b>(8 marks)</b>			
<b>Notes</b>			
<b>(a)</b>	<b>M1:</b> Attempt to differentiate 2 <sup>nd</sup> line of cdf in the form $k(x+1)$ (oe) or 3 <sup>rd</sup> line of cdf in the form $m(4-x)$ (oe) <b>A1:</b> Correct probability density function. (Condone missing “0 otherwise” and mis-use of < or $\leq$ , etc )		
<b>(b)(i)</b>	<b>1<sup>st</sup> B1:</b> Correct shape. Triangle must have both ends on axis		
<b>(ii)</b>	<b>2<sup>nd</sup> B1:</b> Correct labels. All three needed.		
	<b>dB1:</b> Correct description of <u>positive</u> skew. <b>Dep</b> on sketch that clearly shows positive skew.		
<b>(c)</b>	<b>1<sup>st</sup> M1:</b> Suitable start to problem e.g. showing $P(1 < X < 2) = 0.25$ o.e. e.g. $F(c) = 0.675$ or $2F(c) = 0.8 + 0.55$ <b>2<sup>nd</sup> M1:</b> Rearranging to form quadratic equation in $c$ can fit their “0.25” e.g. $2c^2 - 16c + 19 = 0$ Allow even if wrong part of $F(x)$ is used so M0M1A0 is possible. <b>A1:</b> 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><math>x</math></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><math>y</math></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><math>d^2</math></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> $\sum d^2 = 162$	$x$	1	2	3	4	5	6	7	8	$y$	7	8	5	6	3	4	2	1	$d^2$	36	36	4	4	4	4	25	49	M1 dM1	3.1a 1.1b
	$x$	1	2	3	4	5	6	7	8																					
	$y$	7	8	5	6	3	4	2	1																					
	$d^2$	36	36	4	4	4	4	25	49																					
	$r_s = 1 - \frac{6 \times \text{"their"} \sum d^2}{8(8^2 - 1)}$	M1	1.1b																											
	$r_s = -0.9285...$ awrt <u><b>-0.929</b></u>	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																														
<p><b>1<sup>st</sup> B1:</b> Both hypotheses correct in terms of <math>\rho_s</math> or <math>\rho</math></p> <p><b>1<sup>st</sup> M1:</b> for an attempt to rank both rows (at least 4 correct in one row or 2 pairs). Condone reverse rankings.</p> <table><tr><td><math>x</math></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><math>y</math></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><math>d^2</math></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> $\sum d^2 = 6$ <p><b>2<sup>nd</sup> dM1:</b> dep on 1<sup>st</sup> M1 for attempt at <math>d</math> or <math>d^2</math> row for their rankings.</p> <p><b>3<sup>rd</sup> M1:</b> for use of <math>1 - \frac{6 \times \text{"162"}}{8(8^2 - 1)}</math> Allow independently of 1<sup>st</sup> M1 and 2<sup>nd</sup> M1</p> <p><b>1<sup>st</sup> A1:</b> awrt <math>-0.929</math> allow <math>-\frac{13}{14}</math> or <math>-0.928</math> following a correct expression</p> <p>Allow for <math>+0.929</math> etc following correct reverse ranking using <math>\sum d^2 = 6</math></p> <p><b>2<sup>nd</sup> B1:</b> correct critical value (allow <math>\pm 0.8333</math>). 4dp here but allow 3 in 2<sup>nd</sup> A1</p> <p><b>2<sup>nd</sup> A1ft:</b> dependent upon all M marks and <math> r_s  = 0.929</math> <b>or</b> <math> cv  = 0.833</math>(or better) No incorrect statements e.g. “accept <math>H_0</math> there is evidence of negative ...” If comparison is seen it must be correct: e.g. <math>-0.929 &gt; -0.833</math> <b>or</b> <math>-0.929 &lt; 0.833</math> are both A0 Allow “insufficient evidence of negative rank correlation” provided it follows from <u>their</u> <math>r_s</math> and their cv (at least one of which must be correct).</p>				$x$	1	2	3	4	5	6	7	8	$y$	2	1	4	3	6	5	7	8	$d^2$	1	1	1	1	1	1	0	0
$x$	1	2	3	4	5	6	7	8																						
$y$	2	1	4	3	6	5	7	8																						
$d^2$	1	1	1	1	1	1	0	0																						

Question	Scheme	Marks	AOs
<b>3(a)</b>	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>(b)</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)	
<b>(c)</b>	$E(Y) = \int_0^3 \frac{1}{24} y(y+2)(4-y) dy$ or $\int_0^3 \frac{1}{24} (8y + 2y^2 - y^3) dy$	M1	1.1b
	$E(Y) = \frac{1}{24} \left[ 4y^2 + \frac{2}{3}y^3 - \frac{y^4}{4} \right]_0^3 \rightarrow \frac{1}{24} \left[ (36 + 18 - \frac{81}{4}) - (0) \right] [= \frac{45}{32}]$	M1	1.1b
	$\text{Var}(Y) = E(Y^2) - [E(Y)]^2 = \frac{213}{80} - \left( \frac{45}{32} \right)^2 [= \frac{3507}{5120}]$	M1	1.1b
	$\text{Var}(2Y) = 4\text{Var}(Y)$	M1	3.1a
	$= \frac{3507}{1280} = 2.73984... \text{ awrt } \underline{2.74}$	A1	1.1b
		(5)	
<b>(9 marks)</b>			
<b>Notes</b>			
<b>(a)</b>	<b>M1:</b> Attempt to find the mode e.g. diff'n, complete the square or sketch in (a) <b>A1*:</b> fully correct justification, must <u>show</u> or <u>explain</u> why a max e.g. reference to negative quadratic (and 1 is in $[0,3]$ ). Allow "decreasing function"		
<b>(b)</b>	<b>M1:</b> use of symmetry or other method e.g. calculator to determine $P(Y < 2)$ <b>A1:</b> for median is less than 2 with correct reasoning $\text{M1 for attempt at } F(y) = \frac{1}{24} \left( -\frac{y^3}{3} + y^2 + 8y \right) \text{ and } F(y) = \frac{1}{2}$ Condone missing $\frac{1}{24}$ for M1 <b>A1</b> for awrt 1.37 and comment with some evidence that $F(y) = \frac{1}{2}$ attempted		
<b>(c)</b>	<b>1<sup>st</sup> M1:</b> Attempt to integrate $yf(y)$ – ignore limits here.   <b>Must see algebraic</b> Need to see at least one $y^n \rightarrow y^{n+1}$   <b>integration for 1<sup>st</sup></b> <b>2<sup>nd</sup> M1:</b> Substitution of correct limits into integral of $yf(y)$   <b>and 2<sup>nd</sup> M1</b> Don't need to <u>see</u> limits used if intention is clear and answer correct. <b>3<sup>rd</sup> M1:</b> Attempt to find variance i.e. <u>use</u> of $E(Y^2) - [E(Y)]^2$ ft their $E(Y)$ <b>4<sup>th</sup> M1:</b> Use of $\text{Var}(2Y) = 2^2 \text{Var}(Y)$ . Independent of 1 <sup>st</sup> ~ 3 <sup>rd</sup> M1 <b>A1:</b> (dep on all Ms) for $\frac{3507}{1280}$ or awrt 2.74		

Question	Scheme	Marks	AOs
<b>4(a)</b>	$E(X) = \underline{4.5}$	B1	1.1b
		(1)	
<b>(b)</b>	$[P(1 < X < 4) = P(2 < X < 4) =] \frac{2}{5}$	B1	1.1b
		(1)	
<b>(c)</b>	$2X^2 - 15X + 27 > 0 \rightarrow [\{X < 3\} \cup \{X > 4.5\}]$	M1	3.1a
	$P(\{X < 3\} \cup \{X > 4.5\}) = \frac{3-2}{7-2} + \frac{7-4.5}{7-2} \left[ = 1 - \frac{4.5-3}{7-2} \right]$	M1	1.1b
	$= \frac{7}{10} \text{ or } \underline{0.7}$	A1	1.1b
		(3)	
<b>(d)</b>	$E\left(\frac{3}{X^2}\right) = \int_2^7 \frac{3}{x^2} \times \frac{1}{(7-2)} dx$	M1	3.1a
	$= [-0.6x^{-1}]_2^7$	M1	1.1b
	$= \frac{3}{14}$	A1	1.1b
		(3)	
<b>(8 marks)</b>			
<b>Notes</b>			
<b>(a)</b>	<b>B1:</b> 4.5 oe		
<b>(b)</b>	<b>B1:</b> $\frac{2}{5}$ oe		
<b>(c)</b>	<b>1<sup>st</sup> M1:</b> Attempting to find roots. Can be implied by sight or use of 3 and 4.5 <b>2<sup>nd</sup> M1:</b> 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 $0.2 \times 0.5$ is M0M1A0 <b>A1:</b> $\frac{7}{10}$ oe		
<b>(d)</b>	<b>1<sup>st</sup> M1:</b> use of $E(g(x))$ by setting up correct integral (ignore limits) <b>2<sup>nd</sup> M1:</b> integration with limits <b>A1:</b> $\frac{3}{14}$ oe from correct working		



Question	Scheme	Marks	AOs
<b>5(a)</b>	$S_{ss} = \frac{S_{sh}}{b} = \frac{0.352}{0.919} [= 0.383...] \text{ or } \frac{352}{919}$	M1	2.1
	$r = \frac{0.352}{\sqrt{0.377 \times 0.383}}$	M1	1.1b
	$r = 0.9263...$ awrt <b>0.926</b>	A1	1.1b
		<b>(3)</b>	
<b>(b)</b>	$h - 1.68 = 0.919(1.79 - 1.70)$	M1	3.4
	$h = 1.76271$ awrt <b>1.76</b>	A1	1.1b
		<b>(2)</b>	
<b>(c)</b>	$S_{ss}$ 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
		<b>(3)</b>	
<b>(8 marks)</b>			
<b>Notes</b>			
<b>(a)</b>	<b>1<sup>st</sup> M1:</b> realising the need to find $S_{ss}$ Must have $0.919 = \frac{0.352}{S_{ss}}$ or better <b>2<sup>nd</sup> M1:</b> attempt to find $r$ fit their $S_{ss}$ provided $S_{ss} > 0.33$ <b>A1:</b> awrt 0.926		
<b>(b)</b>	<b>M1:</b> 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 <b>A1:</b> awrt 1.76		
<b>(c)</b>	<b>1<sup>st</sup> M1:</b> explaining the effect on $S_{ss}$ <b>2<sup>nd</sup> M1:</b> considering the effect on $S_{sh}$ <b>A1:</b> correct deduction		
<b>ALT</b>	<b>1<sup>st</sup> M1</b> explaining that $s_{25} = \bar{s}$ so point lies on $s = \bar{s}$ Must be explicit <b>2<sup>nd</sup> M1</b> $h_{25} > \bar{h}$ so the <u>line would move upwards (parallel to original regression line)</u> <b>A1</b> correct deduction		

