Pearson Edexcel

# Mark Scheme

## Summer 2023

Pearson Edexcel GCE

Advanced Subsiduary Level

Further Mathematics (8FM0)

Paper 24 : Further Statistics 2

Final

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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 <u>and indicates which response they wish to submit</u>, examiners should mark this response.
   If there are several attempts at a question <u>which have not been crossed out</u>, examiners should mark the final answer which is the answer that is the <u>most complete</u>.

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.

# 8FM0-24 May 2023 Final

| Question | Scheme | Marks | AOs |
|---|---|---|---|
| 1(a) | | M1<br>M1 | 1.1b<br>1.1b |

| Applicant / Task | $A$ | $B$ | $C$ | $D$ | $E$ | $F$ | $G$ | $H$ | $I$ |
|---|---|---|---|---|---|---|---|---|---|
| $P$ | 1 | 3.5 | 3.5 | 6 | 8 | 2 | 6 | 6 | 9 |
| $Q$ | 2 | 5.5 | 4 | 8 | 9 | 1 | 3 | 5.5 | 7 |

| Question | Scheme | Marks | AOs |
|---|---|---|---|
| | $\sum p^2 = 282.5 \quad \sum q^2 = 284.5 \quad \sum pq = 271.25$ | | |
| | $r_s = \dfrac{"271.25" - \frac{45\times 45}{9}}{\sqrt{\left("282.5" - \frac{45^2}{9}\right)\left("284.5" - \frac{45^2}{9}\right)}}$ Must be using ranks | M1 | 1.1b |
| | $r_s = 0.7907...$ awrt 0.791 | A1 | 1.1b |
| | | **(4)** | |
| (b) | $H_0 : \rho = 0 \quad H_1 : \rho > 0$ | B1 | 2.5 |
| | Critical Value $\rho = 0.7833$ | B1 | 1.1b |
| | $r_s = 0.7907$ lies in the critical region/reject $H_0$/significant | M1 | 2.1 |
| | There is evidence of a positive correlation between the ranks of <u>scores</u> for tasks $P$ and $Q$ | A1ft | 2.2b |
| | | **(4)** | |
| (c) | $P$ and $R$ are not in agreement so they will give <u>different</u> information about the applicants (oe) <u>or</u><br>$P$ and $Q$ and $Q$ and $R$ are in some agreement so they will give <u>similar</u> information about the applicants (oe) | M1 | 2.4 |
| | $P$ and $R$ | A1 | 2.2b |
| | | **(2)** | |
| | | | **(10 marks)** |

## Notes

| | | |
|---|---|---|
| **(a)** | **M1:** | For an attempt to rank at least one row (at least 4 correct) [May have no tied ranks] |
| | **M1:** | For an attempt to rank both rows using tied ranks (at least 4 correct) |
| | **M1:** | for those who have incorrect rankings but show some working of<br>$r_s = \dfrac{"271.25" - \frac{45\times 45}{9}}{\sqrt{\left("282.5" - \frac{45^2}{9}\right)\left("284.5" - \frac{45^2}{9}\right)}}$ May be implied by a correct answer |
| | **A1:** | awrt 0.791 (NB 0.796 is M1M1 M1A0) |
| | **ALT** | For use of $\sum d^2 = 1^2 + 2^2 + 0.5^2 + 2^2 + 1^2 + 1^2 + 3^2 + 0.5^2 + 2^2 \left[= 24.5\right]$ - allow use of "their $d$" and<br>$r_s = 1 - \dfrac{6\times "24.5"}{9\times 80} (= 0.7958...)$ they can get M1M1M1A0 (But dep on <u>some</u> attempt to rank) |
| **(b)** | **B1:** | Both hypotheses stated in terms of $\rho$ or $\rho_S$ |
| | **B1:** | for the correct critical value of 0.7833 (use of pmcc 0.7498 is B0) |
| | **M1:** | for comparing their 0.791 with their 0.7833 (could have 0.7498) and making a correct statement |
| | **A1ft:** | For a correct ft contextual conclusion with no contradictions seen.<br>Must mention "scores" <u>and</u> either "task" or "$P$ and $Q$" |
| **(c)** | **M1:** | For a correct explanation to support their answer. Must have idea of "different" or "similar" tasks |
| | **A1:** | for a correct deduction from the information i.e. choosing $P$ and $R$ only |

| Question | Scheme | Marks | AOs |
|---|---|---|---|
| 2(a) | $\int_{[1]}^{[t]} \frac{9x}{16} - \frac{x^3}{16}\,dx = \left[\frac{9x^2}{32} - \frac{x^4}{64}\right]_{[1]}^{[t]}$ <u>or</u> $\frac{9x^2}{32} - \frac{x^4}{64}[+c]$ | M1 | 1.1b |
| | $F(x) = \begin{cases} 0 & x < 1 \\ \frac{9x^2}{32} - \frac{x^4}{64} - \frac{17}{64} & 1 \leqslant x \leqslant 3 \\ 1 & x > 3 \end{cases}$ | B1<br>A1 | 1.1b<br>1.1b |
| | | **(3)** | |
| (b) | $P(X > 1.8) = 1 - F(1.8)$ oe | M1 | 1.1b |
| | $= 0.5184$ | A1 | 1.1b |
| | | **(2)** | |
| (c) | $E(X^{-1}) = \int_1^3 x^{-1}\left(\frac{9}{16}x - \frac{1}{16}x^3\right)dx$ <u>or</u> $\int_1^3 \frac{9}{16} - \frac{1}{16}x^2 dx$ | M1 | 1.1b |
| | $E(3X^{-1} + 2) = 3 \times \left[\frac{9}{16}x - \frac{1}{48}x^3\right]_1^3 + 2$ <u>or</u> $3 \times \frac{7}{12} + 2$ | dM1 | 1.1b |
| | $= 3.75$ | A1 | 1.1b |
| | | **(3)** | |
| **Alternative** | $E(3X^{-1} + 2) = \int_1^3 \left(\frac{9}{16}x - \frac{1}{16}x^3\right)(3x^{-1} + 2)dx$ | M1 | |
| | $= \left[\frac{27}{16}x - \frac{1}{16}x^3 + \frac{9}{16}x^2 - \frac{1}{32}x^4\right]_1^3$ | M1 | |
| (d) | $\frac{df(x)}{dx} = \frac{9}{16} - \frac{3}{16}x^2$ | M1 | 1.1b |
| | $\frac{9}{16} - \frac{3}{16}x^2 = 0$ | dM1 | 1.1b |
| | $\frac{3}{16}x^2 = \frac{9}{16} \Rightarrow x = \sqrt{3}$ * **and** either a sketch <u>or</u> full statement | A1cso* | 2.1 |
| | | **(3)** | |
| | | **(11 marks)** | |

**Notes**

| | | |
|---|---|---|
| (a) | **M1:** | for correct method to integrate f($x$). e.g. $\frac{(9-x^2)^2}{-64}$ or $1 - \frac{(9-x^2)^2}{64}$ Allow one sign error. |
| | **B1:** | 1st and 3rd line correct need $x < 1$ and $x > 3$ |
| | **A1:** | for correct middle line including $1 \leqslant x \leqslant 3$ |
| (b) | **M1:** | for a correct method to find prob. Must have 1 – … and 1.8 substituted into their F($x$) |
| | **A1:** | awrt 0.518 <u>or</u> $\frac{324}{625}$ |
| (c) | **M1:** | for a correct expression to find $E(X^{-1})$ or $E(3X^{-1} + 2)$ |
| | **dM1** | for an attempt to integrate their correct expression (at least 1 term correct) |
| | **A1:** | 3.75 oe [NB E($X$) = 1.85 leading to $E(3X^{-1} + 2) = \frac{134}{37} = 3.62...$ scores M0M0A0] |
| (d) | **M1:** | for differentiating f($x$) with at least one term correct |
| | **dM1** | for setting up an equation to find the mode. Allow subst of $\sqrt{3}$ |
| | **A1 cso*** | $x = \sqrt{3}$ and either a sketch through (0, 0), (3, 0) and showing max between them <u>or</u> statement to show mode not on the boundary $f(\sqrt{3}) = 0.6495... > 0.5$ f(1) = 0.5 and f(3) =0 |

| Question | Scheme | Marks | AOs |
|---|---|---|---|
| 3(a) | $\left[ S_{vv} = 526407.8 - \frac{2174.9^2}{9} = 831.132... \right] S_{vv} = 831.132$ | | |
| | $r = \frac{5.1376}{\sqrt{"831.132" \times 0.0487}}$ | M1 | 1.1b |
| | $r = 0.80753...$ awrt 0.808 | A1 | 1.1b |
| | | **(2)** | |
| (b) | [Positive] correlation reasonably close to 1 is consistent with a linear relationship<br>or strong (oe eg "high") positive correlation, so is consistent | B1ft | 2.4 |
| | | **(1)** | |
| (c) | $b = \frac{5.1376}{0.0487}$ [= 105.49…] | M1 | 3.3 |
| | $a = \frac{2174.9}{9} - "105.49..." \times \frac{17.63}{9}$ or $a = 241.655.. - "105.49.." \times 1.958..$ | M1 | 1.1b |
| | $v = 105.5h + 35.0$ | A1 | 1.1b |
| | | **(3)** | |
| (d) | The sum of the residuals should be zero | B1 | 2.4 |
| | | **(1)** | |
| (e) | Residual = 2.27 – 1.04 [=1.23] | M1 | 3.1b |
| | $v = "105.5" \times 1.96 + "35.0" + "1.23"$ | M1 | 3.4 |
| | = 243.01 awrt 243 | A1ft | 1.1b |
| | | **(3)** | |
| | | | **(10 marks)** |

| Notes | | |
|---|---|---|
| **(a)** | **M1:** | for a complete correct method to find $r$. Correct expressions for $S_{vv}$ and $r$ |
| | **A1:** | for awrt 0.808 |
| **(b)** | **B1ft** | ft their answer to part (a). For a correct reason.<br>If $r < 0.58$ allow "weak" correlation or correlation is close to 0 so is **not** consistent |
| **(c)** | **M1:** | for use of a correct model. i.e. a correct expression for $b$ (or 105 or better) |
| | **M1:** | for use of a correct model i.e. a correct expression (ft) for $a$ (or 35 or better) |
| | **A1:** | for the equation on the regression line with $b$ =105.5 or awrt 105<br>and $a$ = awrt 35.0 [ condone $a$ = 35 but not awrt 35] |
| **(d)** | **B1:** | for a correct explanation |
| **(e)** | **M1:** | for a correct method to calculate the actual residual |
| | **M1:** | for using the model to estimate the speed. Must be $\hat{v}$ + their actual residual (using 2.27…) |
| | **A1ft** | for awrt 243 or ft their values of $a$ and $b$ |

| Question | Scheme | Marks | AOs |
|---|---|---|---|
| 4(a) | $\mathrm{P}(-4 < X < 2) = \mathrm{P}(-3 < X < 2)$ | M1 | 1.1b |
| | $\frac{2+3}{k+3} = \frac{1}{3}$ <u>or</u> $k = 2 + 2 \times (2 - -3)$ | M1 | 1.1b |
| | $k = 12$ | A1 | 1.1b |
| | | **(3)** | |
| (b) | $\frac{a+b}{2} = 6$ **and** $\frac{1}{12}(b-a)^2 = 192$ | M1 | 3.1a |
| | $\frac{1}{12}(a-(12-a))^2 = 192$ <u>or</u> $\frac{1}{12}((12-b)-b)^2 = 192$ (oe) | M1 | 1.1b |
| | $a = -18$ <u>or</u> $b = 30$ | A1 | 1.1b |
| | $\mathrm{P}(Y > 7.5) = \frac{"30" - 7.5}{"30" - ("-18")}$ $\left[ = \frac{15}{32} \text{ or } 0.46875 \text{ (accept 0.469 or better)} \right]$ | M1 | 3.4 |
| | $R \sim \mathrm{B}(5, "0.46875")$ | M1 | 3.3 |
| | $\mathrm{P}(R \geqslant 2) = 0.7710...$ | A1 | 1.1b |
| | | **(6)** | |
| | | | **(9 marks)** |

| Notes | | |
|---|---|---|
| **(a)** | **M1:** | for realising they need to consider $\mathrm{P}(-3 < X < 2)$ |
| | **M1:** | for a correct equation for $k$ <u>or</u> allow $\frac{2+4}{k+3} = \frac{1}{3}$ $[\rightarrow k = 15]$ <u>or</u> $k = 2 + 2 \times (2 - -4)[= 14]$ |
| | **A1:** | 12 cao [NB M0M1A0 is possible here, often implied by $k = 15$] |
| **(b)** | **M1:** | for translating the problem into 2 correct equations (using 6 and 192) |
| | **M1:** | for a correct method used to eliminate $a$ or $b$ (e.g. an equation in $a$ or $b$)<br>also allow for $a + b = 12$ and $b - a = 48$ |
| | **A1:** | for a correct <u>single</u> value for $a$ <u>or</u> $b$ ($a = 30$ and $b = -18$ is A0) |
| | **M1:** | for using their model to find $\mathrm{P}(Y > 7.5) = p$ [$\mathrm{P}(Y < 7.5) = \frac{17}{32}$ is M0 unless it leads to 0.771] |
| | **M1:** | for stating or using the correct model i.e. B(5, $p$) where $p$ is a probability based on $Y$ and 7.5<br>NB use of B(5, $\frac{17}{32}$) is OK here and typically scores M0M1A0 |
| | **A1:** | for awrt 0.771 |

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