# Mark Scheme (Results)

## Summer 2024

Pearson Edexcel GCE
In Mathematics (9MA0)
Paper 31 Statistics

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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 50.

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
   - $\overline{\phantom{x}}$ 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.

| Qu 1 | Scheme | Marks | AO |
|---|---|---|---|
| **(a)** | $X$~B(10, $\frac{1}{6}$) [Allow 0.167 or better for $\frac{1}{6}$] | M1 | 3.3 |
| **(i)** | [P($X$ = 3) = ] 0.155045… **awrt <u>0.155</u>** | A1 | 1.1b |
| **(ii)** | [P($X$ < 3) = P($X$ „ 2) =] 0.775226… **awrt <u>0.775</u>** | A1 | 1.1b |
| | | **(3)** | |
| **(b)** | [Let $D$ = no. of days when $X$ = 3] $D$~B(60, "0.155") | M1 | 3.3 |
| | P($D$ …12) = 1 – P($D$ „ 11) [Allow 1 – P($D$ < 12)] | M1 | 3.4 |
| | = 1 – 0.78819… **awrt <u>0.212</u>** | A1 | 1.1b |
| | | **(3)** | |
| **(c)** | [$n$ = 600, $p$ = $\frac{1}{6}$ ] estimate = **<u>100</u>** | B1 | 3.4 |
| | | **(1)** | |
| **(d)** | [$S$ = total no. of sixes over 60 days. ] $S \approx T \sim \mathrm{N}\left("100", \sqrt{\frac{5}{6}\times 100}^{2}\right)$ | M1A1 | 3.3,1.1b |
| | P($S$ > 95) ≈ P($T$ > 95.5) <u>or</u> $\mathrm{P}\left(Z > \frac{95.5-"100"}{"9.128..."}\right)$ <u>or</u> P($Z$ > −0.49..) | M1 | 3.4 |
| | = 0.688976… **awrt <u>0.689</u>** | A1 | 1.1b |
| | | **(4)** | |
| | | **(11 marks)** | |

**Notes**

**If you see any attempt using an *n*-sided die with *n* not equal to 6 please send to review.**

**(a)** M1 for sight or use of the correct distribution. <u>Must</u> have B, or Bin or Bpd or Bcd **and** the correct value for $n$ and $p$, just $n$ = 10, $p$ = $\frac{1}{6}$ is M0

Implied by one answer correct to 2dp <u>or</u> by sight of $\binom{10}{3}\left(\frac{1}{6}\right)^3\left(\frac{5}{6}\right)^7$ or one of :

[P($X$ = 0) =] **0.16**(1…),[P($X$ = 1) =] **0.32**(3…), [P($X$ = 2) =] **0.29**(0…), [P($X$ „ 3) =] **0.93**(0…)

**(i)** 1st A1 for awrt 0.155

**(ii)** 2nd A1 for awrt 0.775

**(b)** 1st M1 for selecting a correct model. Sight or use of correct binomial, ft their (a)(i)
May be implied by sight of [P($D$ „ 11) = ] 0.78… or 0.79 <u>or</u> [P($D$ „ 12) = ] 0.87…

2nd M1 for correct interpretation of "at least 12" and writing or using 1 – P($D$ „ 11)
**We are <u>not</u> attempting to ft their incorrect 0.155 on our calculators here.**

A1 for awrt 0.212 [Answer only 3/3]

**(c)** B1 for 100 but must be seen in part (c) i.e. between (b) and (d)

**(d)** 1st M1 for attempting normal **with mean = 100** <u>or</u> ft their answer to (c)
May be implied by the correct mean and a correctly labelled s.d. ($\sigma$) or var ($\sigma^2$)

1st A1 for correctly labelled standard deviation allow $\sqrt{\frac{250}{3}} = \sqrt{83.3...}$ = 9.1(28….) <u>or</u> correctly labelled variance. Implied by N( $\mu, \frac{250}{3}$ ) <u>or</u> correct answer.

2nd M1 for attempt at continuity correction i.e. sight of 95 <u>+</u> 0.5

2nd A1 for awrt 0.689 [Answer only 4/4]

**NB** **If they don't state the model for 1st M1 but just give probabilities with probability statements (*Y* is any letter):**

$\sigma = \frac{250}{3} =$ 1st M1 implied by: P($Y$ > 94.5) = 0.52(63…), P($Y$ > 95) = 0.52(39…), P($Y$ > 95.5) = 0.52(15..)

**No cc** 1st M1 1st A1 implied by: P($T$ > 95) = 0.70(805…)

1st M1 1st A1 2nd M1 implied by: P($T$ > 94.5) = 0.72(657…)

**Exact binomial** gives 0.68567… and will likely score 0/4

| Qu 2 | Scheme | Marks | AO |
|---|---|---|---|
| **(a)** | e.g. The height ($h$) decreases by about 1.28 m for each second of the flight | B1 **(1)** | 3.4 |
| **(b)** | $H_0 : \rho = 0$ $H_1 : \rho < 0$ | B1 | 2.5 |
| | [5% 1-tail cv = ] (±) 0.5494 | M1 | 1.1a |
| | [$r$ = – 0.510 not sig] there is insufficient (o.e.) evidence of a negative correlation between height (or $h$ ) and time (or $t$ ) | A1 **(3)** | 2.2b |
| **(c)** | No – since points seem to follow a curve/quadratic (rather than a line) or since points are "non-linear" but regression line/ model is linear<br>or e.g. between ($t$ = 5 and 7 )height drops by much more than 2.56 m<br>or e.g. gradient is positive up to $t$ = 3.5 (line gradient < 0)<br>or e.g. gradient is positive initially (line gradient < 0)<br>or e.g. gradient is positive and then negative | B1 **(1)** | 2.4 |
| **(d)** | [ $h = 38.1 - 0.78\left(t-k\right)^2$ with] a suitable $k$ i.e. in the range 3~4.5 | B1 **(1)** | 3.3 |
| | | **( 6 marks)** | |

| | **Notes** |
|---|---|
| **(a)** | B1 for a suitable interpretation in context [value can be 1.3 or 1.28 or "just over 1"] per sec<br>Must have underlined words (o.e.) and units "m"or metres and "s" or seconds<br>NB "descends" implies "height decreases"<br>Condone e.g. "decreases by – 1.28 m" |
| **(b)** | B1 for both hypotheses correct in terms of $\rho$ [accept a $p$ or p but not $r$ or r]<br>Must be attached to $H_0$ and $H_1$<br>M1 for a critical value corresponding to their $H_1$:<br>1-tail: awrt ± 0.549 **or** 2-tail (B0 scored for $H_1$) : awrt ± 0.632 (tables 0.6319)<br>If hypotheses are in words and can deduce whether one or two-tail then use their words.<br>If no hypotheses or their $H_1$ is not clearly one or two-tail assume one-tail<br>A1 a correct conclusion in context mentioning correlation and height and time<br>A comparison or statement such as "not sig" is not needed but if seen must be correct.<br>Do NOT award this A mark if contradictory comments or working seen e.g. "reject $H_0$"<br>or comparison of 0.510 with significance level of 0.05 or e.g. – 0.549 > – 0.510 |
| **NB** | Can award B0M1A1 |
| **SC** | **B0(**for 2-tail) **M0**(for cv = ± 0.549) **scored:** Allow 1 mark (score as B0M0A1) for conclusion such as: "insufficient evidence of (negative) correlation between height and time of flight" |
| **(c)** | B1 for saying no **and** giving a suitable supporting reason<br>Don't allow "correlation" on its own instead of "gradient"<br>B0 for simply saying "points don't lie close to a straight line" Need mention of curve or some other feature of scatter plot that differs from regression line.<br>B0 for just "non-linear" without mention of the model being linear<br>B0 for simply comparing 1 or 2 points – need a comment about general pattern |
| **(d)** | B1 for a value of $k$ in the range [3, 4.5] Do not need $k$ = …<br>Accept a value embedded in Jane's model. ISW any errors in multiplying out bracket. |

| Qu 3 | Scheme | Marks | AO |
|---|---|---|---|
| **(a)** | Rain[fall] (allow [Mean] Windspeed) | B1 **(1)** | 1.2 |
| **(b)** | $[\bar{x} =]$ 15.2239… = awrt **15.2** | B1 | 1.1b |
| | $\sigma_x = \sqrt{\frac{44\,695.4}{184} - "15.22.."^2}$ or $\sqrt{11.1(422...)}$ | M1 | 1.1b |
| | = 3.33800… awrt **3.34** | A1 **(3)** | 1.1b |
| **(c)** | Mean is higher than average **OR** a summer/spring month<br>If they say winter/autumn they must explain that these are hotter months for Perth.<br>[Perth is southern hemisphere or Australia so latest available] month is **Oct** | M1<br>A1cso **(2)** | 2.4<br>2.2b |
| | | **( 6 marks)** | |

| | **Notes** |
|---|---|
| | **Answers may appear next to the question.** |
| **(a)** | B1 for Rain[fall] or precipitation (e.g. allow Daily Total [or Mean or max] Rainfall etc)<br>(or allow Mean Windspeed or just "windspeed" BUT not max windspeed or "gust")<br>If they give more than one answer we take the **last one**.<br>(NB Actual windspeed mean is 8.2, sd 2.38. No other quantitative variables available) |
| **(b)** | B1 for awrt 15.2 (Do not accept fractions or mixed numbers)<br>M1 for a correct expression including square root (ft their mean)<br>May be implied by an answer of 3.3 or better.<br>A1 for awrt 3.34<br>[Allow $s$ = 3.3471… i.e. awrt 3.35 if correct formula/expression is seen] |
| | **If answer in (b)(i) > 19.4 and an attempt is made in (c) please send to review.** |
| **(c)** | M1 for a reason mentioning that mean or temperature is higher (o.e.)<br>e.g. it is a warmer/hotter month is OK<br>or sight of 19.4 > (their) 15.2<br>Only ft their 15.2 if it is less than 19.4<br>**OR** suggesting a summer/spring month.<br>Ignore incorrect statements that are irrelevant or don't contradict<br>For incorrect statements that contradict score M0<br>A1cso dep on M1 scored for inferring October<br>Must choose just October not a range like August~October<br>(NB actual mean for Sep is 15.6 and sd 3.19 and this scores A0)<br><br>Can accept for example "high mean so December" for M1A0 |
| **SC** | M1A1 for "October since Perth is in the southern hemisphere/Australia"<br>M1A0 for "Sep or Nov or Dec or Jan or Feb **and** "Perth is in the southern hemisphere/Australia"<br>M0A0 just "Perth is in the southern hemisphere/Australia" without a month M0A0 |

| Qu 4 | Scheme | Marks | AO |
|---|---|---|---|
| **(a)** | $H_0 : p = 0.1$ $H_1 : p \neq 0.1$ [Allow 10% for 0.1] | B1 | 2.5 |
| | [$X \sim B(40, 0.1)$] $\Rightarrow$ $P(X = 0) = 0.0148$ [Allow any letter for $X$] | M1 | 3.3 |
| | $P(X \ldots 9) = 1 - P(X \,„\, 8) = 1 - 0.9845 = 0.0155$ | A1 | 1.1b |
| | Critical region is $\{X = 0\} \cup \{X \ldots 9\}$ (o.e.) | A1 | 1.1b |
| | | **(4)** | |
| **(b)** | ["0.0148" + "0.0155" ] = 0.0303 | B1ft | 1.1b |
| | | **(1)** | |
| **(c)** | [Provided 7 is not in their CR ] insufficient evidence to support Freya's belief | B1 | 2.2b |
| | | **(1)** | |
| | | **( 6 marks)** | |

**Notes**

**Mark (a) and (b) together for sight of the probabilities.**

**(a)** B1 for both hypotheses in terms of $p$ or $\pi$. Must be attached to $H_0$ and $H_1$

M1 for use of the correct model. Implied by sight of at least one probability truncated or rounded to at least 2sf from: 0.0155, 0.0148, 0.0805, 0.9845, 0.9581, 0.9949
Implied by sight of fully correct CR (with no probs) so e.g. $X = 0$, $X > 8$ scores M1A0A0

1st A1 for at least one correct probability (to at least 3sf) with its probability statement
i.e. for $P(X = 0)$ = awrt 0.0148 or $P(X \ldots 9)$ = awrt 0.0155

2nd A1(**dep on M1 and 1st A1** but not on B1)
for both correct probs (to at least 3 sf) and the correct critical region
Do not need set notation. Allow $X < 1$ and $X > 8$ or words e.g. "0 or greater than 8" etc
Allow "," or "and" or "or" or "$\cap$" between $X \,„\, 0$ and $X \ldots 9$
$P(X = 0)$ and $P(X \ldots 9)$ is 2nd A0

**(b)** B1ft for awrt 3.03% or correct sum of their two probabilities (provided each is less than 0.5)
Their probabilities must be to at least 2sf and relate to their CR

**To score in (c) they must have a CR of the form ($X = 0$ or $X < a$)and $X > b$, where $b$ is …7**
**May be implied by $P(X < a)$ and $P(X > b)$ i.e. 2nd A0 in (a) but correct form. Need $b > a$**

**(c)** B1 for a suitable comment in context that suggests no support for Freya's belief/claim
**or** e.g. insufficient evidence of change in proportion/percentage of left-handed adults
**or** e.g. proportion/percentage of left-handed adults is not different from 10% ( **or** …is 10% )
**or** e.g. 10% of adults in the country are left-handed
Do not allow contradictory comments e.g. "in CR so no support for Freya's belief" is B0

**NB** A correct contextual answer in (c) using an **acceptance region** please send to review.

| Qu 5 | Scheme | Marks | AO |
|---|---|---|---|
| **(a)** | [P($H > 1.6$) = ] 0.091211… = awrt **0.0912** | B1 **(1)** | 1.1b |
| **(b)** | Need $H$ and $T$ to be independent<br>or events $\{H > 1.6\}$ and $\{T < 300\}$ are independent | B1 **(1)** | 2.4 |
| **(c)** | [P($T < 300$) =] 0.124(2816…)<br>Prob both is: "0.0912..."×"0.124..."<br>= 0.011335… = awrt **0.0113** | M1<br>M1<br>A1 **(3)** | 3.4<br>1.1b<br>1.1b |
| **(d)** | $\frac{16.3-\mu}{\sigma} = -0.5244(0051...)$ , $\frac{29-\mu}{\sigma} = 1.2816$ (calc: 1.28155156…)<br>e.g. $29-16.3 = \sigma("1.2816"-"-0.5244")$<br>$\sigma = 7.032115...$ = awrt **7.03**<br>$\mu = 19.9876...$ = **19.95** „ **$\mu$** „ **20.0** | M1M1<br>M1<br>A1<br>A1 **(5)** | 3.1a<br>1.1b<br>1.1b<br>1.1b<br>3.2a |
| | | **( 10 marks)** | |

| | Notes |
|---|---|
| **(a)** | B1 for awrt 0.0912 (from calculator) |
| **(b)** | B1 for a suitable reason mentioning or implying $H$ and $T$ are independent<br>Allow: e.g. "they"/ "each event"/ "P($H$) and P($T$ )"/ "the variables" **and** "independent"<br>B0 for "the results" /"the values" are independent.<br>Ignore other comments that are not incorrect or contradictory. |
| **(c)** | 1st M1 for using model for $T$ to attempt to find P($T < 300$) e.g. sight of 0.124 or better or<br>sight of $\pm\left(\frac{300-330}{26}\right)$ or $\pm\left(\frac{5-5.5}{0.433...}\right)$ or $Z = \pm 1.15(3…)$<br>2nd M1 for multiplying their two probabilities together ft part (a) and their P($T < 300$) provided both values are probabilities. NB M0M1 is possible here<br>A1 for awrt 0.0113 [Correct answer with no incorrect working 3/3] |
| **(d)** | 1st M1 for standardising 16.3 and setting equal to $z$ value where $0.5 < \|z\| < 0.6$<br>2nd M1 for standardising 29 and setting equal to $z$ value where $1 < \|z\| < 1.5$<br>3rd M1 dep on 1st or 2nd M1 for solving their two linear eq'ns – reach an eq'n in one variable<br>May be implied by sight of $\sigma = 7$ (or better) or $\mu = 20$ (or better)<br>**For 1st A mark we must also see one of – 0.5244 or 1.2816 (or better) used in their equ'ns OR both $z$ values correct to 3dp i.e. – 0.524 and 1.282**<br>1st A1 for $\sigma$ = awrt 7.03 (but see 3rd case below)<br>2nd A1 for $\mu$ = in [19.95, 20.0] (i.e shouldn't see something rounding down to 20.0)<br>Allow 20 from equations with suitable $z$ values (see examples below) |
| **NB** | Use of – 0.524 and 1.28 [would give 7.0399… and 19.988…] and scores M3A0A1<br>Use of – 0.524 and 1.2816 [would give 7.033… and 19.99…] and scores M3A1A1<br>Use of – 0.5244 and 1.28 [would give 7.038… and 19.99 …] and scores M3**A1**A1<br><br>Both $z$ values correct to 3dp i.e. – 0.524 and 1.282 [should give 7.032 and 19.984] scores A1A1 |

| Qu 6 | Scheme | Marks | AO |
|---|---|---|---|
| **(a)** | $A, C$ <u>or</u> $A, D$ <u>or</u> $B, D$ [ Allow things like $A \cap D$] | B1 **(1)** | 1.2 |
| **(b)** | $P(C) = 0.6$ <u>and</u> $P(B) = p + 0.32$ <u>and</u> $P(B \cap C) = 0.27$ <br> <u>or</u> $(0.08 + 0.25 + 0.27) \times (0.27 + 0.05 + p) = 0.27$ <u>or</u> $0.27 + 0.05 + p = \frac{0.27}{0.6} = 0.45$ | M1 | 1.1b |
| | [$p + 0.32 = 0.45$ so] $p =$ **<u>0.13</u>** | A1 **(2)** | 2.2a |
| **(c)** | $[P(A \mid B')] = \frac{q}{q + r + 0.25 + 0.08}$ <u>or</u> $\frac{q}{1 - (0.05 + "0.13" + 0.27)}$ <u>or</u> $\frac{q}{0.55}$ | M1 | 2.1 |
| | $q + r = 1 - 0.65 -$ "0.13" [= 0.22] | M1 | 1.1b |
| | Since $r$ …0 the greatest value of $q$ is "0.22" so $P(A \mid B')$,, **<u>0.4</u>** or $\frac{2}{5}$ | A1 **(3)** | 2.2a |
| **(d)** | $[P(B \mid A') =] \frac{0.27 + "0.13"}{0.6 + "0.13" + r} = 0.5$ or $\frac{0.27 + "0.13"}{1 - (q + 0.05)} = 0.5$ | M1 | 1.1b |
| | $r =$ **<u>0.07</u>** , | A1 | 1.1b |
| | $q =$ **<u>0.15</u>** | A1ft **(3)** | 1.1b |
| **(e)** | $\lfloor P([A \cup B]' \cap C) = \rfloor [0.25 + 0.08] =$ **<u>0.33</u>** | B1 **(1)** | 1.1b |
| **(f)** | e.g. $B \cap [A \cup C]'$ <u>or</u> $B \cap A' \cap C'$ <u>or</u> $(B \cap A') \cap (B \cap C')$ o.e. | B1 **(1)** | 1.1b |
| | | **( 11 marks)** | |

**Notes**

**(a)** B1 for a correct pair. If more than one pair is given then all must be correct.
P($A$) and P($C$) etc is B0 $P(A \cap C) = 0$ is B0 **but** condone things like $A \cap C = \varnothing$

**In parts (b) – (d) we will condone poor notation and mark equations/expressions**

**(b)** M1 for all relevant labelled probabilities listed <u>or</u> a correct equation/expression for $p$
A1 for $p = 0.13$

**In parts (c) and (d) they can use letter *p* or we ft their value for *p* provided a probability**

**(c)** 1st M1 for a correct method for $P(A \mid B')$ in $q$ (and $r$) ft their $p$. May be done in stages
e.g. find correct expression for $P(B')$, simplify incorrectly then use $q$ over this
2nd M1 for a correct equation for $q + r$ (o.e.)(ft their $p$) Can accept $r = 0$ and $q = 0.22$
**NB** sight of $\frac{0.22}{0.55}$ will score M1M1
A1 for 0.4 i.e. deducing the maximum value of $P(A \mid B')$. Allow ,, 0.4 or $P(A \mid B') = 0.4$
Can award 3/3 for $P(A \mid B') = 0.4$ but not 0.4 alone as it can come from e.g $P(C')$

**(d)** M1 for a correct equation for $r$ (or $q$) only can have $p$ or ft their value for $p$.
May be in stages
e.g. find $P(A') = 0.27 + 0.25 + 0.08 + p + r$ but make a slip in getting 0.6 then use this.
1st A1 for $r = 0.07$ <u>or</u> $q = 0.15$
2nd A1ft for $r = 0.07$ <u>and</u> $q = 0.15$ <u>or</u> values giving $q + r = 0.22$ provided both $q$ and $r$ are probabilities. Obviously, 2nd A1ft is dependent on the M1

**(e)** B1 for 0.33

**(f)** B1 for any correct expression. Do **not** condone P(…

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