Pearson Edexcel

# Mark Scheme (Results)

## Summer 2021

Pearson Edexcel IAL In Statistics 3
Paper WST03/01

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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 IAL MATHEMATICS

## General Instructions for Marking

1. The total number of marks for the paper is 75.

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
- $\sqcup$ The second mark is dependent on gaining the first mark

4. All A marks are 'correct answer only' (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.

5. 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.

6. If a candidate makes more than one attempt at any question:
   - If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
   - If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.

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

## Summary of changes from Provisional Mark Scheme

A few minor changes were made to the Mark Scheme before marking on the marking service began.

| Question Number | **Summary of changes** |
|---|---|
| **Q05d** | The note was amended. This was added to the note 'Only f.t. = $r - 2$' |

<table>
<tr><th>Question Number</th><th>Scheme</th><th>Notes</th><th>Marks</th></tr>
<tr><td rowspan="2">1(a)</td><td rowspan="2"><table>
<tr><td></td><td>$A$</td><td>$B$</td><td>$C$</td><td>$D$</td><td>$E$</td></tr>
<tr><td>$C$</td><td>3</td><td>2</td><td>1</td><td>5</td><td>4</td></tr>
<tr><td>$M$</td><td>2</td><td>4</td><td>1</td><td>5</td><td>3</td></tr>
<tr><td>$d$</td><td>1</td><td>-2</td><td>0</td><td>0</td><td>1</td></tr>
<tr><td>$d^2$</td><td>1</td><td>4</td><td>0</td><td>0</td><td>1</td></tr>
</table></td><td>Attempt to rank at least 1 row with at least 3 correct. Allow reverse rankings.</td><td>M1</td></tr>
<tr><td>Attempt at $d^2$ for their rankings, can be implied by $\sum d^2 = 6$</td><td>M1</td></tr>
<tr><td></td><td>$\sum d^2 = 6$</td><td>Can be implied by correct answer. Must come from correct rankings.</td><td>A1</td></tr>
<tr><td></td><td>$r_s = 1 - \frac{6(6)}{5(24)}$</td><td>(dep on 1st M1) Use of correct formula with their $\sum d^2$</td><td>dM1</td></tr>
<tr><td></td><td>$r_s = 0.7$</td><td>0.7 o.e.<br>Must come from correct rankings.</td><td>A1</td></tr>
<tr><td></td><td></td><td></td><td>(5)</td></tr>
<tr><td>1(b)</td><td>$\mathrm{H}_0 : \rho = 0,\ \mathrm{H}_1 : \rho > 0$</td><td>Both correct in terms of $\rho$ or $\rho_s$. Must be compatible with their ranking.</td><td>B1</td></tr>
<tr><td></td><td>cv 0.9 or cr $r_s \geq 0.9$</td><td>0.9<br>sign should match $\mathrm{H}_1$ or their $r_s$</td><td>B1</td></tr>
<tr><td></td><td>$r_s = 0.7$ does not lie in cr so do not reject $\mathrm{H}_0$</td><td>Correct non-contextual statement e.g. “do not reject $\mathrm{H}_0$”, “not in critical region”, “not significant”, “no positive correlation”.<br>$|\text{test value}|$ or $|\text{cv}| > 1$ award M0</td><td>M1</td></tr>
<tr><td></td><td>Data does not support plant biologist’s claim.</td><td>Correct conclusion in context. Must mention “biologist’s claim” o.e. or moisture and plant coverage. All previous marks in (b) must have been scored.</td><td>A1ft</td></tr>
<tr><td>SC</td><td colspan="2">For use of two-tailed test:<br>May score B0B1M1A0 for cv = 1(.000) and ‘not significant’ oe</td><td></td></tr>
<tr><td></td><td></td><td></td><td>(4)</td></tr>
<tr><td></td><td></td><td></td><td>Total 9</td></tr>
</table>

<table>
<tr><th>Question Number</th><th>Scheme</th><th>Notes</th><th>Marks</th></tr>
<tr><td>2</td><td>$H_0$ : Diet and health are independent (or not associated).<br>$H_1$ : Diet and health are not independent (or associated).</td><td>“diet” and “health” mentioned at least once. Use of correlation is B0.</td><td>B1</td></tr>
<tr><td></td><td><table>
<tr><th>EXPECTED</th><th>Good health</th><th>Poor health</th><th>Totals</th></tr>
<tr><td>Good diet</td><td>83.19</td><td>10.81</td><td>94</td></tr>
<tr><td>Poor diet</td><td>93.81</td><td>12.19</td><td>106</td></tr>
<tr><td>Totals</td><td>177</td><td>23</td><td>200</td></tr>
</table></td><td>Attempt $\frac{\text{RT}\times\text{CT}}{\text{GT}}$<br>with at least one correct to 1dp;<br>all correct to 1dp.</td><td>M1;<br>A1</td></tr>
<tr><td></td><td><table>
<tr><td>Observed</td><td>Expected</td><td>$\frac{(O-E)^2}{E}$</td><td>$\frac{O^2}{E}$</td></tr>
<tr><td>86</td><td>83.19</td><td>0.095</td><td>88.905</td></tr>
<tr><td>8</td><td>10.81</td><td>0.730</td><td>5.920</td></tr>
<tr><td>91</td><td>93.81</td><td>0.084</td><td>88.274</td></tr>
<tr><td>15</td><td>12.19</td><td>0.648</td><td>18.458</td></tr>
<tr><td colspan="2">Totals</td><td>1.557</td><td>201.557</td></tr>
</table></td><td>Attempt at $\frac{(O-E)^2}{E}$<br>or $\frac{O^2}{E}$ with their values with 2 correct or 2 correct f.t.<br>Allow 2sf for this mark.</td><td>M1</td></tr>
<tr><td></td><td>$\sum\frac{(O-E)^2}{E}$ or $\sum\frac{O^2}{E}-200=1.557$</td><td>awrt 1.6</td><td>A1</td></tr>
<tr><td></td><td>$\nu=(2-1)(2-1)=1$<br>$\chi_1^2(5\%)=3.841$</td><td>1 (may be implied)<br>3.841<br>NB: may see $\chi_3^2(5\%)=7.815$ for f.t.<br>NB: p-value 0.212 but scores B0B0 on its own</td><td>B1<br>B1f.t.</td></tr>
<tr><td></td><td>$\chi^2=1.557$ does not lie in cr so insufficient evidence to reject $H_0$</td><td>For correct non-contextual statement linking their test statistic and their cv.</td><td>M1</td></tr>
<tr><td></td><td>E.g. Diet and health are independent or<br><br>There is no association between diet and health or<br><br>The doctor’s belief is not supported by this data.</td><td>Dependent on a cv of 3.841 and 3rd M1<br>Correct conclusion in context with “diet” and “health” or “doctor”. Condone “connection” or “relationship” but not “correlation”.</td><td>A1ft</td></tr>
<tr><td></td><td></td><td></td><td>(9)</td></tr>
<tr><td></td><td></td><td></td><td>Total 9</td></tr>
</table>

| Question Number | Scheme | Notes | Marks |
|---|---|---|---|
| **3.** | | | |
| **3(a)** | $\bar{x} = \frac{1}{2}(11.52 + 13.75) = 12.635$ | 12.635 (may be implied by correct CI) | B1 |
| | | Use of 1.96 | B1 |
| | $\left(\frac{\sigma}{\sqrt{n}} =\right) \frac{13.75 - 12.635}{1.96} (= 0.56887...)$<br>$\left(\frac{\sigma}{\sqrt{n}} =\right) \frac{13.75 - 11.52}{2 \times 1.96} (= 0.56887...)$ | For attempt at standard error (may be implied by awrt 0.569) | M1 |
| | | Use of 1.6449 or better (1.644853…from calc)<br>Use of 1.64 or 1.65 is B0 | B1 |
| | $12.635 \pm 1.6449 \times 0.56887...$ | For<br>$(\text{their } \bar{x}) \pm (\text{their } 1.6449)\left(\text{their } \frac{\sigma}{\sqrt{n}}\right)$<br>$\text{their } \frac{\sigma}{\sqrt{n}}$ must be numerical | M1 |
| | 90% CI is $(11.699..., 13.5707...)$ | awrt $(11.7, 13.6)$ from correct working<br>Correct answer with no working scores B1B1M1B0M1A1 | A1 |
| | | | (6) |
| **3(b)** | $4 \times 0.9^3 \times 0.1$<br>$= 0.2916$ | $4p^3(1-p)$ (where $0 < p < 1$)<br>awrt 0.292 | M1<br>A1 |
| | | | (2) |
| | | | **Total 8** |

| Question Number | Scheme | Notes | Marks |
|---|---|---|---|
| **4. (a)** | Label academic (1-1680) and vocational (1-2520) | For numbering/labelling/ordering (o.e.) students in **each** group | B1 |
| | Use **random** numbers to select from each group. | For use of random sample/numbers/selection | B1 |
| | 28 academic and 42 vocational | Both numbers correct with the associated group | B1 |
| | | | (3) |
| **4(b)** | $\mathrm{H}_0 : \mu_v - \mu_a = 0$<br>$\mathrm{H}_1 : \mu_v - \mu_a > 0$ | If the hypotheses are given in terms of $\mu_a - \mu_b$, *a* and *b* must be defined. | B1 |
| | $\text{se} = \sqrt{\frac{70}{80} + \frac{60}{50}}$ | Correct attempt at se – condone slip in sample sizes. | M1 |
| | $z = \frac{62-57}{\sqrt{\frac{70}{80} + \frac{60}{50}}}$ | Dep on previous M1 standardising with (62 – 57) and their se (Allow $\pm$) | dM1 |
| | $z = 3.471...$<br>(or probability of 0.0003) | awrt $\pm 3.47$<br>(or awrt 0.0003) | A1 |
| | cv $z = 1.6449$ | Allow $\pm$ but signs must be compatible<br>Or allow comparison with probability of 0.05 | B1 |
| | Reject $\mathrm{H}_0$ / significant | Dependent on 2nd M1. A correct non-contextual statement based on their **normal** cv and their test statistic. | dM1 |
| | There is evidence that the **mean(o.e.)** basic skills score for **vocational** students is greater than the **mean** basic skills score for **academic** students. | Correct comment in context. Must mention "mean", "academic" and "vocational".<br>Allow f.t. on their normal cv and their test statistic. | A1f.t. |
| | | | (7) |
| **4(c)** | Mean / $\bar{X}_a$ (basic skills) score for academic students and mean/ $\bar{X}_v$ (basic skills) score for vocational students… | Must mention **both** means. | B1 |
| | …have (approximately) a normal distribution (as sample sizes are large.) | Must mention normal. | B1 |
| | | | (2) |
| **4(d)** | Sample**s** are (large enough) so that $s^2 = \sigma^2$ | Must imply for both samples | B1 |
| | | | (1) |
| **4(e)** | Test no longer significant so insufficient evidence to reject $\mathrm{H}_0$ | Can be implied by correct comment in context. | M1 |
| | Insufficient evidence that mean (basic skills) **score** for vocational students is greater than the mean (basic skills) **score** for academic students/There is no longer a difference in **scores**/Academic students have improved their mean (basic skills) **score**. | Must mention scores (o.e). | A1 |
| | | | (2) |
| **4(f)** | The course was **effective** (o.e.) | Dep on a significant result in (b) and a non-significant result in (e) | B1 |
| | | | (1) |
| | | | **Total 16** |

<table>
<tr><th>Question Number</th><th>Scheme</th><th>Notes</th><th>Marks</th></tr>
<tr><td>5.(a)</td><td>Relief of symptoms is either a “success” or a “failure”.<br>The probability the medicine being a success is constant.<br>Samples from different medical practices are independent.</td><td>Any 2. Context required in one assumption.</td><td>B1 B1</td></tr>
<tr><td></td><td></td><td></td><td>(2)</td></tr>
<tr><td>5(b)</td><td>$\text{Mean} = \dfrac{0\times4+1\times6+2\times3+...+8\times2}{50} = 3.54*$</td><td>At least two correct terms on the numerator and 50 on the denominator,<br>fully correct expression or $\dfrac{177}{50}$<br>dep on M1 scored cso.</td><td>M1,<br>A1cso</td></tr>
<tr><td></td><td></td><td></td><td>(2)</td></tr>
<tr><td>5(c)</td><td>$p = \dfrac{3.54}{8} = 0.4425$</td><td>Can be implied by at least 1 correct value for $f$ or $g$.</td><td>B1</td></tr>
<tr><td></td><td>$f = 50\times C_4^8\times0.4425^4\times0.5575^4 = 12.96$<br>$g = 50\times0.4425^8 = 0.07$</td><td>Use of Bin(50, $p$) for M1,<br>Allow awrt 12.96, awrt 0.07</td><td>M1A1A1</td></tr>
<tr><td></td><td></td><td></td><td>(4)</td></tr>
<tr><td>5(d)</td><td>$H_0$ : Binomial distribution is a suitable model<br>$H_1$ : Binomial distribution is not a suitable model</td><td>Both hypotheses correct<br>If parameters used then B0.</td><td>B1</td></tr>
<tr><td></td><td><table>
<tr><th>No of successes</th><th>$O$</th><th>$E$</th><th>$\dfrac{(O-E)^2}{E}$</th><th>$\dfrac{O^2}{E}$</th></tr>
<tr><td>0,1,2</td><td>13</td><td>11.66</td><td>0.154</td><td>14.494</td></tr>
<tr><td>3</td><td>12</td><td>13.07</td><td>0.088</td><td>11.018</td></tr>
<tr><td>4</td><td>10</td><td>12.96</td><td>0.676/7</td><td>7.716</td></tr>
<tr><td>5,6,7,8</td><td>15</td><td>12.31</td><td>0.588/7</td><td>18.278</td></tr>
<tr><td></td><td>50</td><td>50</td><td>1.506</td><td>51.506</td></tr>
</table></td><td>Combining 0,1,2 or 5,6,7,8.<br>M1 for attempting $\dfrac{(O-E)^2}{E}$ or $\dfrac{O^2}{E}$<br>with at least 2 correct expressions or 2 correct values to 2sf.</td><td>M1<br>M1</td></tr>
<tr><td></td><td>$\sum\dfrac{(O-E)^2}{E} = \sum\dfrac{O^2}{E} - 50 = 1.50...$</td><td>awrt 1.5 (calculator: 1.50498…)</td><td>A1</td></tr>
<tr><td></td><td>$\nu = 4-2 = 2, \chi_2^2(10\%) = 4.605$</td><td>2 can be implied by 4.605 seen<br>Only f.t. $\nu = r-2$</td><td>B1<br>B1f.t.</td></tr>
<tr><td></td><td>Insufficient evidence to reject $H_0$</td><td>For correct non-contextual statement linking their test statistic and their cv.</td><td>M1</td></tr>
<tr><td></td><td>Data is consistent with a binomial distribution (oe)</td><td>A correct comment suggesting that binomial model is suitable / good fit.<br>Hypotheses wrong way around scores A0 here. Condone parameters here.</td><td>A1</td></tr>
<tr><td></td><td></td><td></td><td>(8)</td></tr>
<tr><td></td><td></td><td></td><td>Total 16</td></tr>
</table>

| Question Number | Scheme | Notes | Marks |
|---|---|---|---|
| **6(a)** | $W = B - 1.1R$ | May be implied by correct mean or variance | M1 |
| | $W \sim \mathrm{N}(55 - 1.1\times 51, 1.3^2 + 1.1^2 \times 1.2^2)$ or<br>$W \sim \mathrm{N}(-1.1, 3.4324)$ | $(\pm)1.1$, awrt 3.43<br>(may be seen in standardisation) | A1, A1 |
| | $\mathrm{P}(W < 0) \quad = \mathrm{P}\left(Z < \dfrac{0+1.1}{\sqrt{3.4324}}\right)$ | Standardising with their mean and their sd. leading to a probability > 0.5 | M1 |
| | $= \mathrm{P}(Z < 0.5937...)$ | | |
| | $= 0.7224$ or $0.7237$ | **awrt 0.72** | A1 |
| | | | (5) |
| **6(b)** | $X = B_1 - B_2$ | May be implied by correct mean or variance | M1 |
| | $X \sim \mathrm{N}(55 - 55, 2\times 1.3^2)$ or $X \sim \mathrm{N}(0, 3.38)$ | $0, 3.38$ | A1, A1 |
| | $\mathrm{P}\left(Z > \dfrac{1-0}{\sqrt{3.38}}\right)$ or $\mathrm{P}\left(Z < \dfrac{-1-0}{\sqrt{3.38}}\right)$ | dep on 1st M1 for standardising with their mean and their sd. | dM1 |
| | $\mathrm{P}(\lvert X \rvert > 1) \quad = 2\times \mathrm{P}(X > 1)$ | For $2\times$ seen or implied | M1 |
| | $= 2\times \mathrm{P}(Z > 0.5439...) \quad = 2\times(1 - 0.7054)$ | $2\times 0.2946$ or<br>$2\times 0.2932$ (calc) | |
| | $= 0.5892$ | **awrt 0.59** | A1 |
| | | | (6) |
| **6(c)** | $V = B_1 + B_2 + B_3 + B_4 + B_5 + B_6 + B_7 + B_8 + B_9 + B_{10} + S$<br>$Y = R_1 + R_2 + R_3 + R_4 + R_5 + R_6 + R_7 + R_8 + R_9 + R_{10} + R_{11} + S$ | May be implied by either correct distribution | M1 |
| | $V \sim \mathrm{N}(553, 16.94)$ and $Y \sim \mathrm{N}(564, 15.88)$ | Both correct | A1 |
| | $D = Y - V$ so<br>$D \sim \mathrm{N}(11\times 51 - 10\times 55,\ 11\times 1.2^2 + 10\times 1.3^2 + 2\times 0.2^2)$ or<br>$D \sim \mathrm{N}(11,\ 32.82)$ | Attempt at their difference for the mean, and their sum for the variance. | M1 |
| | | $(\pm)11$ and awrt 32.8 | A1 |
| | $\mathrm{P}(D > 0) \quad = \mathrm{P}\left(Z > \dfrac{0-11}{\sqrt{32.82}}\right)$ | dep on 1st M1 for standardising using their mean and their standard deviation leading to a probability > 0.5 | dM1 |
| | $= \mathrm{P}(Z > -1.920...)$ | | |
| | $= 0.9726$ | **awrt 0.973** | A1 |
| | | | (6) |
| | | | **Total 17** |

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