Pearson

# Mark Scheme
# (Final)

# January 2026

International Advanced Level in Statistics S3

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 and can be used if you are using the annotation facility on ePEN:

   - 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)
   - d… or dep – dependent
   - indep – independent
   - dp – decimal places
   - sf – significant figures
   - $*$ – The answer is printed on the paper or ag- answer given
   - $\llcorner$ or d… – 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. If you are using the annotation facility on ePEN, indicate this action by 'MR' in the body of the script.

6. If a candidate makes more than one attempt at any question:
   a) If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
   b) 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.

| Question Number | Scheme | Marks |
|---|---|---|
| 1 | $H_0$ : The aptitude test result is independent of the test centre<br>$H_1$ : The aptitude test result is not independent of the test centre | B1 |
| | Observed / Pass / Fail / Total<br>Centre A / 60 / 30 / 90<br>Centre B / 80 / 30 / 110<br>Total / 140 / 60 / 200 | M1 |
| | Expected / Pass / Fail<br>Centre A / $\frac{140\times90}{200}[=63]$ / $\frac{60\times90}{200}[=27]$<br>Centre B / $\frac{140\times110}{200}[=77]$ / $\frac{60\times110}{200}[=33]$ | M1 |
| | $\sum\frac{(O-E)^2}{E}=\frac{(60-63)^2}{63}+\frac{(80-77)^2}{77}+\frac{(30-27)^2}{27}+\frac{(30-33)^2}{33}$<br>or<br>$\sum\frac{O^2}{E}-200=\frac{60^2}{63}+\frac{80^2}{77}+\frac{30^2}{27}+\frac{30^2}{33}-200$ | dM1 |
| | $=0.8658\ldots$ awrt 0.866 | A1 |
| | $\nu=(2-1)(2-1)=1$ | B1 |
| | $\chi^2_2(0.05)=3.841$ | B1ft |
| | [Do not reject H0/not significant/not in the CR] There is insufficient evidence that aptitude test result differs by test centre | dA1ft |
| | | (8) |

| | Notes | Total 8 |
|---|---|---|
| | **B1** | both hypotheses correct with result and centre (Condone aptitude test and test centre). May be written in terms of association |
| | **M1** | for a correct contingency table. May be implied by awrt 0.866 |
| | **M1** | attempt at $\frac{\text{row total}\times\text{column total}}{\text{total}}$ (can be implied by at least one correct expected value) |
| | **dM1** | dependent on previous M1. For using $\sum\frac{(O-E)^2}{E}$ or $\sum\frac{O^2}{E}-200$<br>(There must be 4 values of $\sum\frac{(O-E)^2}{E}$ or $\sum\frac{O^2}{E}$ calculated) |
| | **A1** | awrt 0.866 |
| | **B1** | $\nu=1$ |
| | **B1ft** | 3.841 (or better) allow ft from their stated degrees of freedom |
| | **dA1ft** | dependent on 3rd M1 and 3rd B1. For a correct contextual conclusion. Must include result and centre. (Condone aptitude test and test centre) |

| Question Number | Scheme | Marks |
|---|---|---|
| 2 (a) | $H_0 : \rho_s = 0$<br>$H_1 : \rho_s > 0$ | B1 |
| | | (1) |
| (b) | $[r_s =]1-\frac{6\sum d^2}{5(24)} \geqslant 0.9$ | M1 B1 |
| | $\sum d^2 \leqslant 2$ So largest possible value is 2* | A1* |
| | | (3) |
| (c) | e.g. $d = 0, 0, 0, 1, -1$ | M1 |
| | So e.g. $A\ B\ C\ E\ D$ | A1 |
| | | (2) |

| | Notes | Total 6 |
|---|---|---|
| (a) | **B1** | for both hypotheses correct in terms of $\rho$ or $\rho_s$. Condone use of $p$ |
| (b) | **M1** | for use of formula for $r$ in an equation or an inequality (condone > rather than $\geqslant$) |
| | **B1** | for 0.9 |
| | **A1*** | answer is given so at least one correct line of working is needed between the M mark and the given answer. Allow $\sum d^2 = 2$ if written as an equation throughout but do not allow $\sum d^2 \geqslant 2$ or $\sum d^2 > 2$ or $\sum d^2 < 2$ |
| (c) | **M1** | for a correct possibility for $d$ or $\lvert d \rvert$ May be implied by a correct possibility for rankings |
| | **A1** | for a correct possibility for rankings or eg 1, 2, 3, 5, 4 |

| Question Number | Scheme | Marks |
|---|---|---|
| 3 (a) | $\bar{x} = \left[\dfrac{509.1572 + 510.8428}{2} =\right] 510$ | B1 |
| | $2 \times 1.96 \times \dfrac{\sigma}{\sqrt{n}} = 510.8428 - 509.1572$ | M1 |
| | $\dfrac{\sigma}{\sqrt{n}} = 0.43$ | A1 |
| | $'510' \pm 1.6449 \times '0.43'$ | M1 B1 |
| | $(509.292..., 510.707...)$ (awrt 509.3, awrt 510.7) | A1 |
| | | (6) |
| (b) | Let $X$ = The number of confidence intervals containing $\mu$ so $X \sim B(3, 0.9)$ | |
| | $P(X \geqslant 1) = 1 - P(X = 0) = 1 - \left[{}^3C_0 \times 0.9^0\right] \times 0.1^3$ | M1 |
| | $= 0.999$ | A1 |
| | | (2) |
| | **Notes** | **Total 8** |
| (a) | **B1** for $\bar{x} = 510$ | |
| | **M1** for use of $2 \times z$ value $\times \dfrac{\sigma}{\sqrt{n}} = 510.8428 - 509.1572$ oe | |
| | **A1** Cao | |
| | **M1** for use of $\bar{x} \pm z$ value $\times \dfrac{\sigma}{\sqrt{n}}$ ft their $\bar{x}$ and their $\dfrac{\sigma}{\sqrt{n}}$ | |
| | **B1** $z = 1.96$ or better and $z = 1.6449$ or better | |
| | **A1** (awrt 509.3, awrt 510.7) | |
| (b) | **M1** for writing or using $P(X \geqslant 1) = 1 - P(X = 0)$ or $P(X = 1) + P(X = 2) + P(X = 3)$ | |
| | **A1** Cao | |

| Question Number | Scheme | Marks |
|---|---|---|
| 4 (a) | $\frac{273}{150\times10}=0.18$ | M1 A1 |
| | | (2) |
| (b) | ${}^{10}C_5\times0.18^5\times0.82^5\times150[=2.65]$ * | B1* |
| | | (1) |
| (c) | 0.54 | B1 |
| | | (1) |
| (d) | To ensure that no expected frequency < 5 | B1 |
| | | (1) |
| (e) | $H_0$ : Binomial distribution is a good fit.<br>$H_1$ : Binomial distribution is not a good fit | B1 |
| | Combine cells<br>8 + 6 + 3 = 17 and 10.05 + 2.65 + '0.54' = 13.24 | M1 |
| | $\sum\frac{(O_i-E_i)^2}{E_i}=2.51+\frac{(17-13.24)^2}{13.24}$ | M1 |
| | = 3.5777 awrt 3.58 | A1 |
| | $\nu=5-1-1=3$ | B1 |
| | $\chi^2_3(0.05)=6.251$ | B1ft |
| | [Do not reject $H_0$/not significant] Binomial distribution is a suitable model | dA1 |
| | | (7) |

| | Notes | | Total 12 |
|---|---|---|---|
| (a) | **M1** | for a correct method to find the value of *p* | |
| | **A1** | Awrt 0.18 | |
| (b) | **B1*** | for a correct expression for *r* | |
| (c) | **B1** | for 0.54 | |
| (d) | **B1** | for a correct explanation | |
| (e) | **B1** | for both hypotheses correct (any mention of B(10, *p*) is B0) | |
| | **M1** | for combining cells | |
| | **M1** | Dep on an attempt to combine cells. Use of 2.51 + $\sum\frac{(O_i-E_i)^2}{E_i}$ for remaining cells | |
| | **A1** | awrt 3.58 | |
| | **B1** | $\nu=3$ | |
| | **B1ft** | 6.251 or better. Allow ft from their stated DoF | |
| | **dA1** | dependent on 2nd M1. For a correct conclusion which states that the data are consistent with a binomial distribution which must be consistent with the test statistic and CV<br>(Condone any mention of *n* and *p* or it supports the managers belief) | |

| Question Number | Scheme | Marks |
|---|---|---|
| 5 (a) | $\left[ m = \frac{3085}{50} \Rightarrow \right] \quad m = 61.7$ | B1 |
| | $v = \frac{190457.2 - 50(61.7)^2}{50-1} \quad = 2.3$ | M1 A1 |
| | | (3) |
| (b) | $H_0 : \mu_A - \mu_B = 10$<br>$H_1 : \mu_A - \mu_B > 10$ | B1 |
| | $z = \frac{72.2 - '61.7' - 10}{\sqrt{\frac{6.4}{50} + \frac{'2.3'}{50}}}$ | M1 M1 |
| | $= 1.1986...$ awrt 1.20 | A1 |
| | One tailed c.v. $Z = 1.6449$ **or** CR: $Z \geqslant 1.6449$ | B1 |
| | Not in CR/Not significant/Do not reject $H_0$ | M1 |
| | No significant evidence to support the **head of department's claim** | A1 |
| | | (7) |
| (c) | Assume that $s^2 = \sigma^2$ for **both** samples | B1 |
| | Assume sample sizes are large enough so that **CLT** applies or the **CLT** allows us to assume that the distributions of the sample means are (approximately) normal | B1 |
| | | (2) |

| | **Notes** | **Total 12** |
|---|---|---|
| (a) | **B1** | Cao |
| | **M1** | for a full attempt at $s^2$ ft their $\bar{x}$ |
| | **A1** | Cao |
| (b) | **B1** | for both hypotheses correct in terms of $\mu_A$ and $\mu_B$ Allow equivalent rearrangements. Allow other letters as long it is clear which is professor A and which is professor B. Must be attached to $H_0$ and $H_1$ |
| | **M1** | for $z = \frac{a - b - 10}{\sqrt{\frac{c}{50} + \frac{d}{50}}}$ with at least 2 of $a$, $b$, $c$ or $d$ correct (allow ±) ft their 61.7 and their 2.3 |
| | **M1** | for $z = \frac{72.2 - '61.7' - 10}{\sqrt{\frac{6.4}{50} + \frac{'2.3'}{50}}}$ (allow ±) ft their 61.7 and their 2.3 |
| | **A1** | awrt 1.20 |
| | **B1** | for CV = ±1.6449 and compatible sign with their test statistic |
| | **M1** | for correct statement consistent with their test statistic and CV (no contradictory non-contextual comments) May be implied by correct contextual comment on its own |
| | **A1** | for a contextual conclusion that is consistent with their test statistic and their CV. Must mention head of department's claim |
| (c) | **B1** | for one correct assumption. Must mention **both** samples. |
| | **B1** | for a second correct assumption. Must mention **both** samples. |

| Question Number | Scheme | Marks |
|---|---|---|
| 6 (a) | $\left[\mathrm{P}\left(\bar{H}<55.08\right)=0.1151\right]\Rightarrow\dfrac{55.08-\mu}{\frac{6}{\sqrt{n}}}=-1.20$ | M1 |
| | $55.08+\dfrac{7.2}{\sqrt{n}}=\mu$ | A1 |
| | $\left[\mathrm{P}\left(\bar{H}>56.976\right)=0.0250\right]\Rightarrow\dfrac{56.976-\mu}{\frac{6}{\sqrt{n}}}=1.96$ | M1 |
| | $56.976-\dfrac{11.76}{\sqrt{n}}=\mu$ | A1 |
| | $55.08+\dfrac{7.2}{\sqrt{n}}=56.976-\dfrac{11.76}{\sqrt{n}}$ | M1 |
| | Either $\dfrac{18.96}{\sqrt{n}}=1.896$ or $\sqrt{n}=10$ leading to $n = 100$* | A1* |
| | | (6) |
| (b) | $\mu=55.08+\dfrac{7.2}{'10'}=55.8$ or $\mu=56.976-\dfrac{11.76}{'10'}=55.8$ | M1 A1 |
| | | (2) |
| | **Notes** | **Total 8** |

| | | |
|---|---|---|
| (a) | **M1** | for standardising with $\mu$ and $\dfrac{6}{\sqrt{n}}$ and setting = to ± 1.2 |
| | **A1** | for a correct equation |
| | **M1** | for standardising with $\mu$ and $\dfrac{6}{\sqrt{n}}$ and setting = to ± 1.96 |
| | **A1** | for a correct equation |
| | **M1** | for solving simultaneously |
| | **A1*** | for a correct equation leading to the given answer |
| (b) | **M1** | substitution of $n$ = their 10 into an equation to find $\mu$ |
| | **A1** | Cao |

| Question Number | Scheme | Marks |
|---|---|---|
| 7 (a) | $\mathrm{E}(\bar{X}) = \dfrac{(a-1)+(a+5)}{2} = a+2$ | M1 A1 |
| | So $\bar{X} - 2$ is an unbiased estimator for $a$ | A1 |
| | | |
| | | (3) |
| (b) | $\mathrm{SE}(\bar{X} - 2) = \mathrm{SE}(\bar{X})$ | B1ft |
| | $\mathrm{Var}(X) = \dfrac{\left((a+5)-(a-1)\right)^2}{12} = 3$ | M1 A1 |
| | $\mathrm{SE} = \dfrac{s}{\sqrt{n}} = \dfrac{\sqrt{3}}{3} = 0.57735...$ awrt 0.577 | M1 A1 |
| | | (5) |

| | **Notes** | | **Total 8** |
|---|---|---|---|
| (a) | **M1** | for use of $\dfrac{a+b}{2}$ | |
| | **A1** | for a + 2 | |
| | **A1** | Cao | |
| (b) | **B1ft** | for $\mathrm{SE}(\bar{X} - 2) = \mathrm{SE}(\bar{X})$ ft their unbiased estimator in part (a) May be implied by awrt 0.577 | |
| | **M1** | for use of $\dfrac{(b-a)^2}{12}$ | |
| | **A1** | Cao | |
| | **M1** | for use of $\dfrac{s}{\sqrt{n}}$ | |
| | **A1** | awrt 0.577 | |

| Question Number | Scheme | Marks |
|---|---|---|
| 8 (a) | $[a =]625+625-886=]364$ | B1 |
| | $[b =]42^2+42^2+45^2=5553$ | M1 A1 |
| | | (3) |
| (b) | $X = L - 3S$ | |
| | $\left[\mathrm{E}(X)=886-3\times265=\right]91$ | M1 |
| | $\left[\mathrm{Var}(X)=\right]45^2+3^2\times78^2=56781$ | M1 A1 |
| | $\left[\mathrm{P}(X>0)=\right]\mathrm{P}\left(Z>\dfrac{0-91}{\sqrt{56781}}\right)$ | M1 |
| | $\left[\mathrm{P}(Z>-0.38)=\right]0.6480$ Cal gives 0.64865… So awrt 0.648 – 0.649 | A1 |
| | | (5) |
| (c) | $Y=\dfrac{S_1-S_2}{2}$ $\quad R=S_1-S_2$ | M1 |
| | $\left[\mathrm{E}(Y)=\dfrac{265-265}{2}=\right]0$ $\quad \left[\mathrm{E}(R)=265-265=\right]0$ | M1 |
| | $\left[\mathrm{Var}(Y)=\right]\dfrac{78^2+78^2}{4}=3042$ $\quad \left[\mathrm{Var}(R)=\right]78^2+78^2=12168$ | M1 |
| | $\left[\mathrm{P}(Y>100)=\right]\mathrm{P}\left(Z>\dfrac{100-0}{\sqrt{3042}}\right)$ $\quad \left[\mathrm{P}(R>200)=\right]\mathrm{P}\left(Z>\dfrac{200-0}{\sqrt{12168}}\right)$ | M1 |
| | $\left[\mathrm{P}(Z>1.81)=1-0.9649=\right]0.0351$ Cal gives 0.0349 So awrt 0.0349 – 0.0351 | A1 |
| | | (5) |

| | | Notes | Total 13 |
|---|---|---|---|
| (a) | **B1** | Cao | |
| | **M1** | For writing or using $2\times\mathrm{Var}(M)+\mathrm{Var}(L)$ | |
| | **A1** | Cao | |
| (b) | **M1** | for seeing or using E($X$) = 91 or correct expression for mean | |
| | **M1** | for writing or using $\mathrm{Var}(L)+3^2\mathrm{Var}(S)$ | |
| | **A1** | Cao | |
| | **M1** | for standardising using their mean and standard deviation (Allow ±) | |
| | **A1** | awrt 0.648 – awrt 0.649 | |
| (c) | **M1** | for use of $\frac{S_1-S_2}{2}$ or $S_1-S_2$ | |
| | **M1** | for writing or using E($Y$) = 0 or E($R$) = 0 | |
| | **M1** | for using Var ($Y$) = 3042 or Var($R$) = 12168 | |
| | **M1** | for standardising using their mean and standard deviation (Allow ±) | |
| | **A1** | awrt 0.0349 – awrt 0.0351 | |