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# Mark Scheme (Results)

## January 2020

## Pearson Edexcel International Advanced Level in Statistics S1 (WST01) Paper 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.

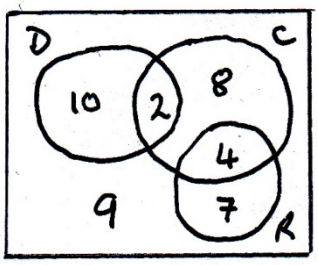
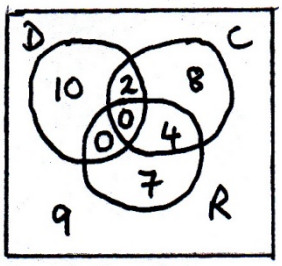
## Special notes for marking Statistics exams (for AAs only)

- Any correct method should gain credit. If you cannot see how to apply the mark scheme but believe the method to be correct then please send to review.
- For method marks, we generally allow or condone a slip or transcription error if these are seen in an expression. We do not, however, condone or allow these errors in accuracy marks.
- If a candidate is "hedging their bets" e.g. give Attempt 1…Attempt 2…etc then please send to review.

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| Question Number | Scheme | Marks |
|---|---|---|
| **1.** | [Sum of probs = 1 gives] $a+b+c+0.3=1$ (o.e.)<br>[F(1) = 0.63 gives ] $0.15 + a + b = 0.63$ or $0.63 + c + 0.15 = 1$ (o.e.)<br>Solving $c = \mathbf{\underline{0.22}}$<br>[Use of E($X$) = 1 or symmetry gives ] $a = c$ $a = \mathbf{\underline{0.22}}$<br>Therefore $b = \mathbf{\underline{0.26}}$ | M1<br>M1<br>A1<br>M1<br>A1<br>**[5]** |
| | **Notes** | |
| | **Each of the 3 Ms can be awarded at any point for either the correct equation seen or clearly implied by its use e.g. choosing their $b$ ( $0 < b < 0.7$) so that $a + b + c = 0.7$ (1st M1)**<br>1st M1 for use of sum of probabilities to form an equation in $a$, $b$ and $c$.<br>Can allow the use of their value for $c$ in the equation or implied by its use to find $b$<br>2nd M1 for equation in $a$ and $b$ from using F(1) = 0.63 e.g. $a + b = 0.48$ or $c + 0.15 = 0.37$<br>1st A1 for deducing $c = 0.22$<br>3rd M1 for using E($X$) = 1 to deduce $a = c$ ft their value of $c$ (provided $0 \leqslant a \leqslant 0.35$ )<br>NB E($X$) = 1 gives $-a + b + 3c = 0.7$ but only scores M1 when they state $a = c$<br>or give their value of $a$ ($0 \leqslant a \leqslant 0.35$ ) = their value of $c$<br>2nd A1 for $b = 0.26$<br>**All 3 correct answers only (no working) scores 5 marks (they may be seen in the table)**<br>If answers seen in the table contradict answers with working in the body of the script the script takes preference. | |

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| Question Number | Scheme | Marks |
|---|---|---|
| **2. (a)** |     | B1 B1 B1 B1 (4) |
| **(b)** | Since no family has a dog and a rabbit a mutually exclusive pair is $\underline{D, R}$ | B1 (1) |
| **(c)** | $\left[\frac{2+"4"}{40}\right] = \underline{\underline{\frac{3}{20}}}$ | B1ft (1) |
| **(d)** | e.g. $P(D \cap C) = \frac{2}{40} = \frac{1}{20}$ $P(D) = \frac{12}{40} = \frac{3}{10}$ $P(C) = \frac{14}{40} = \frac{7}{20}$ or | M1 |
| | $\frac{1}{20} \neq \frac{3}{10} \times \frac{7}{20} = \left[\frac{21}{200}\right]$ so they are not independent | A1 |
| **ALT** | $P(C) = \frac{14}{40} = \frac{7}{20}$ vs $P(C\|D) = \frac{2}{12} = \frac{1}{6}$ or $P(D) = \frac{12}{40} = \frac{3}{10}$ vs $P(D\|C) = \frac{2}{14} = \frac{1}{7}$ | (2) |
| **(e)** | e.g. $\left[P(R \mid C) =\right] \frac{P(R \cap C)}{P(C)}$ or $\frac{"\frac{4}{40}"}{\frac{14}{40}}$ | M1 |
| | $= \frac{4}{14} = \underline{\underline{\frac{2}{7}}}$ | A1ft (2) |
| **(f)** | $\frac{"10"+"7"}{"10"+"7"+9}$ (o.e.) ; = $\underline{\underline{\frac{17}{26}}}$ (accept $0.6\dot{5}38461\dot{}$) | M1; A1 (2) |
| | | **[12]** |

| | Notes |
|---|---|
| **(a)** | 1st B1 for 3 intersecting circles with $n(D \cap R) = 0$ (either diagram) [Blank is not equiv'to 0]<br>2nd B1 for a box and 9 outside the circles<br>3rd B1 for $n(D \cap C) = 2$ and $n(D \cap C') = 10$<br>4th B1 for 8, 4 and 7 correctly placed<br>Allow probabilities (out of 40) or decimals or integers. |
| **(b)** | B1 for $D$ and $R$ with a suitable reason (extra pairs is B0) e.g. $P(D \cap R) = 0$ Condone $\varnothing$ for 0 or no intersection/overlap. Must see an attempt at a reason. Must be $D$, $R$ not $P(D)$ , $P(R)$<br>$P(D \cup R) = P(D) + P(R)$ is not a suitable reason though. |
| | **For (c) onwards if their $N \neq 40$ allow denominators of probs with 40 or $N$** |
| **(c)** | B1ft ft their "4" (but must give a proper fraction) ft blank as 0 or $\frac{3}{20}$ or exact equivalent |
| **(d)** | M1 for stating all the probabilities (values) required for a suitable test, must be labelled. Must use $D$ and $C$ ft their VD. Must be clear which test they are trying to use.<br>A1 for the correct probabilities and correct calculation or comparison and correct conclusion |
| **(e)** | M1 for a correct ratio of probabilities (ft their 4): either as an expression or values<br>A1ft for $\frac{2}{7}$ or exact equivalent (allow ft of their 4 [$\neq 0$] provided it gives an exact fraction) |
| **(f)** | M1 for a correct ratio (possibly of probabilities) ft their 10 and their 7 [Not expression here]<br>A1 for $\frac{17}{26}$ or exact equivalent (e.g. 0.654 will score M1A0) |

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| Question Number | Scheme | Marks |
|---|---|---|
| **3. (a)** | $S_{mp} = 32958 - \frac{1124 \times 281}{10}$ [= 1373.6] **(*)** | B1cso (1) |
| **(b)** | $[r =] \frac{1373.6}{\sqrt{6046.4 \times 382.9}}$ | M1 |
| | = 0.9027… awrt **0.903** | A1 (2) |
| **(c)** | In scatter diagram points are close to a line or $r$ is close to (or near to) 1<br>It is consistent with the manager's belief | B1 (1) |
| **(d)** | $\frac{\sum m}{\sum p} = \frac{1124}{281}$ (o.e) | M1 |
| | So $k =$ **4** | A1 (2) |
| **(e)** | $b = \frac{1373.6}{6046.4}$ [= 0.22717...] | M1 |
| | $a = 28.1 - "0.2271..." \times 112.4$ [ = 2.5653…] | M1 |
| | $p = 2.565\ldots + 0.2271\ldots m$ **$p = 2.57 + 0.227m$** | A1; A1 (4) |
| **(f)** | [2.565…+ 0.2271… × 70 = ] 18.467… accept answers in range **[18, 18.6]** | B1 (1) |
| **(g)** | Manager's model (when $m = 70$) estimates $p = 17.5$<br>So use manager's model since wants the lower estimate. (o.e.) | B1ft<br>dB1 (2) |
| | | **[13]** |

| | Notes |
|---|---|
| **(a)** | B1cso for a correct expression seen (need all 4 numbers seen) |
| **(b)** | M1 for a correct expression or an answer only of 0.90 (2sf) or 0.902 (truncation)<br>A1 for awrt 0.903 |
| **(c)** | B1 for "points close to a line" or "$r$ is close to 1" or "strong correlation" (o.e.)<br>but "nearer to 1" is B0<br>and "consistent with manager" or " consistent with belief" (o.e.) or "yes" |
| **(d)** | M1 for a correct calculation or equation in $k$<br>A1 for $k = 4$ NB using the point (140, 35) is M0A0 despite giving $k = 4$ |
| **(e)** | 1st M1 for a correct expression for $b$<br>2nd M1 for a correct equation in $a$ (ft their value of $b$ or even letter $b$ in correct formula)<br>1st A1 for $b$ = awrt 0.227 in an equation in $p$ and $m$ or allow $y$ and $x$<br>Allow a transciption error (e.g. 0.277 etc) if 0.227 is seen in earlier working.<br>2nd A1 for $a$ = awrt 2.57 in an equation in $p$ and $m$ only |
| **(g)** | 1st B1ft for 17.5 or $70 \div k$ for their value of $k$<br>2nd dB1 (dep on 1st B1) for therefore choosing manager's model because it has the lower estimate. (o.e.) ( Must be true for their values) |

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| Question Number | Scheme | Marks |
|---|---|---|
| **4. (a)** | Width = **0.5** (cm) | B1 |
| | 1cm$^2$ rep's 4 babies or 0.25cm$^2$ rep's 1 baby or their $h \times w = 3.5$ or area = 3.5 cm$^2$ | M1 |
| | Height = $\frac{14}{16} \times 4 \div 0.5 =$ **7** (cm) | A1 |
| | | (3) |
| **(b)** | Lower Quartile = $[2.5] + \frac{\frac{98}{4} - 16}{24} \times 0.5$ $= [2.5] + \frac{8.5}{24} \times 0.5$ | M1 |
| | $= 2.50 + 0.177\ldots$ = awrt **2.68** | A1 |
| | | (2) |
| **(c)** | $Q_2 - Q_1 = 3.14 - "2.68" = \underline{\underline{0.46 > 0.41}} = 3.55 - 3.14 = Q_3 - Q_2$ | M1 |
| | So negative skew | A1 |
| | | (2) |
| **(d)** | $\overline{w} = \frac{311.5}{98} = 3.17857\ldots$ = awrt **3.18** | B1 |
| | $\sigma_w = \sqrt{\frac{1051.125}{98} - \overline{w}^2} = \sqrt{0.622448...}$ ; = 0.78895… = awrt **0.789** | M1 |
| | | A1 |
| | | (3) |
| **(e)** | $\frac{3("3.18" - 3.14)}{"0.789"} = 0.152\ldots$ awrt **0.15** | M1A1 |
| | | (2) |
| **(f)(i)** | 49$^{th}$ value now 3.25 [or median in group $3.25 \leqslant w < 3.50$ ] so median increases | B1 |
| **(ii)** | more higher values or $\Sigma fx$ increases … so mean increases | B1 |
| | | (2) |
| | | **[14]** |

| | **Notes** |
|---|---|
| **(a)** | B1 0.5 only<br>M1 may be implied by correct height<br>A1 correct height of 7(cm) |
| **(b)** | M1 for any correct equation leading to correct fraction as part of $m$ = …or ($m$ – [2.5]) = …<br>Ignore incorrect end point and watch out for "working down" Using 25 for 24.5 is M0<br>A1 awrt 2.68 allow exact fraction e.g. $\frac{257}{96}$ (allow 8.75 for 8.5 [ or $\frac{515}{192}$ ] if $n$ +1 used) |
| **(c)** | M1 for use of $Q_2 - Q_1$ and $Q_3 - Q_2$ (o.e.) ft their $Q_1$ [ or correct inequality and –ve skew]<br>or a correct quartile inequality **and** statement that negative skew<br>A1 for correctly concluding negative skew from their values. Their ft calc should be correct. |
| **(d)** | B1 for awrt 3.18 (allow $\frac{89}{28}$)<br>M1 for a correct expression (including square root) ft their mean ($\frac{\sqrt{122}}{14}$ scores M1)<br>A1 for awrt 0.789 (accept $s$ = 0.79301… = awrt 0.793) |
| **(e)** | M1 for correct substitution (ft their values and condone missing 3)<br>A1 for awrt 0.15 |
| **(f)(i)** | 1$^{st}$ B1 for median increases with a suitable reason to support this (must mention the 3.25) |
| **(ii)** | 2$^{nd}$ B1 for mean increases with a suitable reason to support this (Recalc of $\overline{x} = 3.196...$ is B0) |

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| Question Number | Scheme | Marks |
|---|---|---|
| **5. (a)** | $P(X<7) = P\left(Z < \frac{7-10}{6}\right) = P(Z<-0.5)$ | M1 |
| | $= 1 - 0.6915$ ; $= 0.308537\ldots$ awrt **0.309** | M1; A1 (3) |
| **(b)** | $\frac{10+k-10}{6} = 0.8416$ | M1 B1 |
| | $k = 5.0496$ awrt **5.05** | A1 (3) |
| **(c)** | Area of rectangle is $X(X-3)$ | M1 |
| | Need $X(X-3) > 40$ | M1 |
| | $X^2 - 3X - 40 > 0 \Rightarrow (X-8)(X+5) > 0$ | M1 |
| | So critical values are 8 and $-5$ | A1 |
| | Need $P(X>8) + P(X<-5)$ or $1 - P(-5<X<8)$ | M1 |
| | So $P(Z>-0.33) + P(Z<-2.5)$ | M1 |
| | $= 0.6293 + 0.0062$ | dM1 |
| | $= 0.6355$ $[0.6355 \sim 0.637]$ | A1 (8) **[14]** |

| | Notes |
|---|---|
| **(a)** | 1st M1 for standardising 7 (or 13) with 10 and 6 (allow $\pm$) |
| | 2nd M1 for $1-p$ (where $0.68 < p < 0.70$) |
| | A1 for awrt 0.309 (calc. 0.3085375……) (**Ans only** scores 3/3) |
| **(b)** | M1 Standardising $10 \pm k$ with 10 and 6 and setting equal to $z$ value $0.8 < \lvert z \rvert < 0.9$ |
| | B1 for $z = \pm 0.8416$ or better (calc gives 0.8416212…..) used in a linear equation for $k$ |
| | A1 $k = 5.05$ or better (or use of $z = 0.84$ and answer of 5.04) |
| **Ans only** | awrt 5.04 scores M1B0A1 |
| **Ans only** | Answer in the range 5.049 ~ 5.0499 scores M1B1A1 but answer only of 5.05 is M1B0A1 |
| **(c)** | 1st M1 for a suitable expression for the area of the rectangle (in $x$ or $X$) [$\Rightarrow$ by 2nd or 3rd M1] |
| | 2nd M1 for a correct quadratic inequality (accept $x(x-3) > 40$ [o.e.]) |
| | 3rd M1 for an attempt to solve their 3TQ to find critical values (allow = 0) (e.g. factorise) |
| | Allow $(X+8)(X-5)$ or use of formula with $\leqslant 1$ sign error or $\left(X - \frac{3}{2}\right)^2 - k - 40$ ($k$>0) |
| | 1st A1 for the correct critical values (cvs) of 8 and $-5$ |
| | 4th M1 for solving their quadratic inequality - taking the "outside" region (ft their cvs) [ P(..) not required] |
| | 5th M1 for standardising at least one of their values (with 10 and 6) correctly (ft their cvs) |
| | 6th dM1 for an attempt at both probabilities: one $\approx 0.006$ and one > 0.6 **and adding** or for $1-q$ where $q = 0.36$ or better. This mark is dependent on all the other 5 M marks being scored |
| | 2nd A1 for answer in range [0.6355, 0.637] with clear attempt at both probabilities used (calc 0.636768…) |
| **Ans only** | If 6th M1 is not explicitly seen then must have an answer awrt 0.636 or 0.637 |

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| Qu No. | Scheme | Marks |
|---|---|---|
| **6. (a)** | [Sum of probs = 1 gives] $k\left[1+\frac{1}{2}+\frac{1}{3}+\frac{1}{4}+\frac{1}{5}+\frac{1}{6}\right]$ {=1} <u>or</u> $\frac{147k}{60}=1$ | M1 |
| | $k=\underline{\underline{\frac{20}{49}}}$ | A1 cso |
| | | (2) |
| **(b)** | $\mathrm{E}(S)=\frac{1}{147}\left(60\times\frac{1}{2}+120\times\frac{1}{3}+180\times\frac{1}{4}+240\times\frac{1}{5}+300\times\frac{1}{6}\right)$ <u>or</u> $3.55k$ | M1A1 |
| | $=\underline{\underline{\frac{71}{49}}}$ | A1 |
| | | (3) |
| **(c)** | Expected profit = $260\mathrm{P}(S=5)-10$ **<u>or</u>** $-10\times\mathrm{P}(\mathrm{S}\neq 5)+250\times\mathrm{P}(\mathrm{S}=5)$ | M1M1 |
| | $=\left[260\times\frac{10}{147}-10\right]$ $=7.68707\ldots$ = awrt (\$)**<u>7.69</u>** | A1 |
| | | (3) |
| **(d)** | $p^2$ because Roger must win 1st and 2nd round (accept "wins 2 rounds") | B1 |
| | $(1-p)$ because Roger loses in 3rd round match | B1 |
| | | (2) |
| **(e)** | $[r]$: 0 \| 1 \| 2 \| 3 \| 4 \| 5 <br> $[\mathrm{P}(R=r)]$: $1-p$ \| $p(1-p)$ \| $[p^2(1-p)]$ \| $p^3(1-p)$ \| $p^4(1-p)$ \| $p^5$ | B1 |
| | | M1A1 |
| | | (3) |
| **(f)** | E (profit) = $260\times p^5-10$ | M1 A1 |
| | $\left[\mathrm{E(profit)}\geqslant 7.69\right]\Rightarrow p^5\geqslant\frac{17.69}{260}$ so $p\geqslant 0.58418..$ | M1; A1 |
| | | (4) |
| | | **[17]** |

| | Notes |
|---|---|
| **(a)** | M1 for clear attempt to find sum of probs. (Condone $\frac{147k}{60}=1$) |
| | A1cso for the correct answer with M1 clearly scored and no incorrect working seen. |
| **Verify** | Need to see all 6 probs added and = 1 for M1 and a comment (e.g. therefore $k$ = ... ) for A1 |
| **(b)** | M1 for an attempt at E($S$) – at least 4 correct products (allow use of $k$ or $k$ = 0.408 or better) |
| | 1st A1 for a fully correct expression (allow $3.55k$) |
| | 2nd A1 for $\frac{71}{49}$ (accept 1.45 or better [calc:1.44897…] ) (Ans only 3/3) |
| **(c)** | 1st M1 for $260\times\mathrm{P}(S=5)$ <u>or</u> $250\times\mathrm{P}(S=5)$ \| Probabilities can be in terms of $k$ or ft their values |
| | 2nd M1 for $N\times\mathrm{P}(S=5)-10$ <u>or</u> $N\times\mathrm{P}(S=5)-10\times\mathrm{P}(S\neq 5)$ ( $N\in\mathbb{N}$ ) |
| | A1 for awrt (\$)7.69 |
| **(d)** | 1st B1 for an explanation of the $p^2$ term (e.g. use of tree diagram) \| WWL alone scores 1st B1 <u>but</u> |
| | 2nd B1 for an explanation that must lose the 3rd round match \| WWL <u>and</u> $pp(1-p)$ will get B1B1 |
| **(e)** | B1 for correct set of values for $R$ (in a table or a list) |
| | M1 for at least 3 correct values [apart from P($R$ = 2)] for $R$ and correct probabilities |
| | A1 for a fully correct probability distribution |
| **(f)** | 1st M1 for $260\times\mathrm{P}(R=5)$ (ft their P($R$ = 5) implied by 2nd M1 \| 1st A1 for $260\times p^5-10$ **<u>or</u>** $p^5\geqslant\frac{10}{147}$ |
| | 2nd M1 for forming a correct ft of $\mathrm{P}(R=5)\geqslant\mathrm{P}(S=5)$ (accept > or allow =) [ft their (c)] |
| | 2nd A1 for awrt 0.58 <u>or</u> 0.59 [ If equals sign is used we need to see awrt 0.59 for the A1] |
| **ALT** | $260p^5-10\geqslant 260\times\frac{10}{147}-10$ (M1A1) $\Rightarrow p^5\geqslant\frac{10}{147}$ (M1) etc (A1) |

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