# Mark Scheme (Results)

## January 2021

Pearson Edexcel International A Level
in Statistics S2 (WST02/01)

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January 2021
Publications Code WST02_01_2101_MS

## 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.
- 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
- $\underline{\phantom{x}}$ 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. Ignore wrong working or incorrect statements following a correct answer.

| Question Number | Scheme | | Marks |
|---|---|---|---|
| 1(a) | B(30, 0.05) | | B1 |
| | | | (1) |
| (b) | The **probability**(oe) of an oyster surviving/not surviving is **constant** | | B1 |
| | The survival of each oyster is **independent** of the others | | (1) |
| (c)(i) | ${}^{30}C_{24}(0.05)^6(0.95)^{24}$ oe | | M1 |
| | $= 0.002708\ldots$ | awrt 0.0027 | A1 |
| (ii) | $P(Y \geqslant 3) = 1 - P(Y \leqslant 2)$ from $Y \sim B(30, 0.05)$ or $P(X \leqslant 27)$ from $X \sim B(30, 0.95)$ | | M1 |
| | $= 1 - 0.8122$ | | |
| | $= 0.1878$ | awrt 0.188 | A1 |
| | | | (4) |
| (d) | $A \sim Po(10)$ | | B1 |
| | $P(A \geqslant n) > 0.8$ | | |
| | $P(A \leqslant n-1) < 0.2$ or $P(A \leqslant 6) = 0.1301$....awrt 0.13 or $P(A \geqslant 7) = 0.8699$....awrt 0.87 | | M1 |
| | $n = 7$ | | A1cao |
| | | | (3) |
| (e) | $H_0 : p = 0.05$, $H_1 : p > 0.05$ | | B1 |
| | Using $C \sim B(25, 0.05)$ and $P(C \geqslant 4)$ / Using $D \sim B(25, 0.95)$ and $P(D \leqslant 21)$ | | M1 |
| | $P(C \geqslant 4) = 0.0341$ / CR $C \geqslant 4$ / $P(D \leqslant 21) = 0.0341$ / CR $D \leqslant 21$ | | A1 |
| | Evidence to reject $H_0$, in the CR, significant | | dM1 |
| | There is evidence that the proportion of **oysters** not surviving has **increased**(oe)/**Jim's belief** is supported. | | A1cso |
| | | | (5) |
| | | | **Total 14** |

| Notes | | |
|---|---|---|
| (a) | **B1** | Must include B(inomial), $n = 25$ and $p = 0.05$. Do not allow $p = 0.95$ in part (a) |
| (b) | **B1** | For either correct assumption in context. Ignore extraneous non-contradicting comments. |
| (c)(i) | **M1** | allow ${}^{30}C_6$ oe or $P(X \leq 6) - P(X \leq 5)$ with one correct probability |
| | **A1** | awrt 0.0027 (correct answer scores 2 out of 2) |
| (ii) | **M1** | Writing/using $1 - P(Y \leqslant 2)$ with B(30, 0.05) or writing/using $P(X \leqslant 27)$ with B(30, 0.95) |
| | **A1** | awrt 0.188 (correct answer scores 2 out of 2) |
| (d) | **B1** | Writing or using Po(10) (sight of 0.1301 or 0.8699 can imply this mark) |
| | **M1** | Allow $P(A < n) < 0.2$ or $P(A < 7) =$ awrt 0.13 or $P(A > 6) =$ awrt 0.87 |
| | **A1cao** | $n = 7$ which must come from use of Po(10) or N(10, 9.5) |
| | **Note:** | Use of normal approx. with $\mu = 10$ and $\sigma^2 = 9.5$ leading to $n < 7.4\ldots$can score M1<br>Exact binomial gives $P(A \leqslant 6) = 0.14$ / $P(A \geqslant 7) = 0.86$ scores B0M0A0 |
| (e) | **B1** | Both hypotheses correct (allow use of $p$ or $\pi$). Allow $H_0 : p = 0.95$, $H_1 : p < 0.95$ |
| | **M1** | Using B(25, 0.05) and writing/using $P(C \geqslant 4)$ or if CR given $P(C \geqslant 3)$ using B(25, 0.95) and writing/using $P(D \leqslant 21)$ or if CR given $P(D \leqslant 20)$ |
| | **A1** | Correct probability to 3sf (must not go on and give incorrect CR) or correct CR (ignore upper tail) |
| | **dM1** | (dep on 1st M1) A correct non-contextual statement (do not allow contradicting non-contextual comments) which is consistent with their prob and 0.05 (If not stated, may be implied by A1) |
| | **A1cso** | All previous marks must be awarded. Correct contextual conclusion with bold words (oe) |
| **SC:** | **2-tail** | Use of two-tailed test can score max: B1M1A1M1A0, but must **not reject** $H_0$ for 2nd M1 |

| Question Number | Scheme | | Marks |
|---|---|---|---|
| 2(a) | $1-\mathrm{F}(3.5) = 1-0.97127\ldots$ | | M1 |
| | $= 0.028727\ldots$ | awrt 0.0287 | A1 |
| | | | (2) |
| (b) | $W \sim \mathrm{B}(30,"0.0287")$ | | M1 |
| | $1-\mathrm{P}(W \le 1) = 1-\left((1-"0.0287")^{30} + {}^{30}C_1("0.0287")^1(1-"0.0287")^{29}\right)$ oe | | M1 |
| | $= 1 - 0.78748\ldots = 0.2125\ldots$ | awrt 0.213 to awrt 0.216 | A1 |
| | | | (3) |
| (c) | $\frac{\mathrm{dF}(w)}{\mathrm{d}w} = \frac{1}{3}\left(1-\frac{w^3}{64}\right)$ | | M1 |
| | $\mathrm{E}(W^2) = \int_0^4 \frac{1}{3}\left(w^2 - \frac{w^5}{64}\right)\mathrm{d}w = \frac{1}{3}\left[\frac{w^3}{3} - \frac{w^6}{384}\right]_0^4$ | | dM1 |
| | $= \frac{32}{9}$ | | A1 |
| | $\mathrm{Var}(W) = \frac{32}{9} - 1.6^2$ | | M1 |
| | $= \frac{224}{225}$ | | A1 |
| | | | (5) |
| | | | **Total 10** |

| Notes | | |
|---|---|---|
| (a) | **M1** | For writing or using $1 - \mathrm{F}(3.5)$ Implied by correct answer |
| | **A1** | awrt 0.0287 |
| (b) | **M1** | For writing or using $\mathrm{B}(30,"0.0287")$ allow $n("\text{their } 0.0287")^1(1-"\text{their } 0.0287")^{29}$ ignore any number for $n$ (allow their $p$ to 2sf) |
| | **M1** | For $1-\left((1-"0.0287")^{30} + {}^{30}C_1("0.0287")^1(1-"0.0287")^{29}\right)$ Allow ${}^{30}C_{29}$ in any form |
| | **A1** | allow answer in the range awrt 0.213 to awrt 0.216 |
| (c) | **M1** | Differentiating F($w$) at least one term correct |
| | **dM1** | (Dep on previous M1). Attempting to integrate expanded $w^2$f($w$). At least one $w^n \to w^{n+1}$ Ignore limits for this M mark. |
| | **A1** | awrt 3.56 must come from correct algebraic integration (may be embedded) |
| | **M1** | Use of correct formula with values substituted. Must see the subtraction of $1.6^2$ |
| | **A1** | Dependent upon 2nd M1 awrt 0.996<br>(A correct answer with no algebraic integration seen may score M1M0A0M1A0) |
| | | |

| Question Number | Scheme | | Marks |
|---|---|---|---|
| 3(a) | $P(X \neq 4) = 1 - P(X = 4)$ oe $\left(= 1 - \frac{e^{-7}7^4}{4!} \text{ or } 1 - (0.1730 - 0.0818)\right)$ | | M1 |
| | $= 0.90877\ldots$ | awrt 0.909 | A1 |
| | | | (2) |
| (b) | $P(Y = 1) = (1 - "0.90877...")("0.90877...")^4 \times {}^5C_1$ | | M1M1 |
| | $= 0.311\ldots$ | | A1 |
| | | | (3) |
| (c)(i) | $\lambda = 0.07n$ | | B1 |
| | $A \sim N(0.07n, 0.07n)$ | | M1 |
| | $\frac{3.5 - "0.07n"}{\sqrt{"0.07n"}}$ | | M1 |
| | $\frac{3.5 - 0.07n}{\sqrt{0.07n}} = -1.55$ or $"0.07n" - \left(1.55\sqrt{0.07}\right)\sqrt{n} - 3.5 = 0$ | | B1 |
| | $n - \left(\frac{1.55}{0.07}\sqrt{0.07}\right)\sqrt{n} - \frac{3.5}{0.07} = 0 \Rightarrow n - 1.55\sqrt{\frac{n}{0.07}} - 50 = 0$ | | A1cso |
| | | | (5) |
| (ii) | $\sqrt{n} = \frac{\frac{1.55}{\sqrt{0.07}} \pm \sqrt{\left(\frac{1.55}{\sqrt{0.07}}\right)^2 + 4 \times 50}}{2}$ = awrt – 4.72… or awrt 10.6… ( $4\sqrt{7}$ ) | | M1 |
| | $n = 112$ | | A1cao |
| | | | (2) |
| (d) | $H_0 : \lambda = 7 \quad H_1 : \lambda > 7$ | | B1 |
| | $P(X \geq 15) = 1 - P(X \leq 14)$ $P(X \geq 14) = 0.0128$ | | M1 |
| | $= 1 - 0.9943$ $P(X \geq 15) = 0.0057$ | | |
| | $= 0.0057$ CR $X \geqslant 15$ | | A1 |
| | Reject $H_0$, in the CR, Significant | | dM1 |
| | There is evidence that the number of water **fleas** per 100 ml of the pond water has **increased** | | A1 |
| | | | (5) |
| | | | **Total 17** |

| Notes | | |
|---|---|---|
| (a) | **M1** | For $1 - P(X = 4)$ or $1 - P(X \leq 4) + P(X \leq 3)$ oe |
| (b) | **M1** | $(1 - "\text{their } 0.909")^4 ("\text{their } 0.909")$ or $(1 - "\text{their } 0.909")("\text{their } 0.909")^4$ allow their values to 2s.f. |
| | **M1** | $P(Y = 1) = (1 - "\text{their } 0.909")("\text{their } 0.909")^4 \times {}^5C_1$ allow their values to 2s.f. |
| | **A1** | awrt 0.312 or awrt 0.311 |
| (c)(i) | **B1** | Writing or using mean as $0.07n$ |
| | **M1** | Normal with the mean = variance which must be in terms of $n$ (may be implied by correct standardisation). |
| | **M1** | Standardising with their mean and their $\sqrt{\text{var}}$ . If not stated they must be correct. Allow 2.5, 3, 3.5,4, 4.5 (A **correct** standardisation implies B1M1M1) |
| | **B1** | Their standardisation = $\pm 1.55$ |
| | **A1cso** | Must come from compatible signs in standardisation. Need at least one step between standardisation indicating division by 0.07 and correct equation. |
| (ii) | **M1** | Correct method to solve **given** quadratic <u>or</u> sight of awrt –4.72 or awrt 10.6 |
| | **A1cao** | 112 only (must reject 2nd answer if found) (an answer of 112 only scores M1A1) |
| (d) | **B1** | Both hypotheses correct in terms of $\lambda$ or $\mu$ [using $p$ scores B0] |
| | **M1** | For $1 - P(X \leq 14)$ **or** for CR: one of $P(X \geq 14) = 0.0128$ or $P(X \geq 15) = 0.0057$ |
| | **A1** | awrt 0.0057 or correct CR allow $X > 14$ |
| | **dM1** | (dep on 1st M1) A correct non-contextual statement (do not allow contradicting non-contextual comments) which is consistent with their prob and 0.01. (If not stated, may be implied by A1) |
| | **A1** | All previous marks must be awarded. Correct context. conclusion with increase(oe) and fleas |

| Question Number | Scheme | | Marks |
|---|---|---|---|
| 4(a) | $\int_0^a k(a-x)^2\,\mathrm{d}x = \left[k\left(a^2x - ax^2 + \frac{x^3}{3}\right)\right]_0^a$ or $\left[\frac{-k(a-x)^3}{3}\right]_0^a$ | | M1 A1 |
| | $k\left(a^3 - a^3 + \frac{a^3}{3}\right) = 1$ or $\frac{ka^3}{3} = 1$ $\Rightarrow ka^3 = 3$ | | A1 cso |
| | | | (3) |
| (b) | $\int_0^a kx(a-x)^2\,\mathrm{d}x = \left[k\left(\frac{a^2x^2}{2} - \frac{2ax^3}{3} + \frac{x^4}{4}\right)\right]_0^a$ or $\left[\frac{-kx(a-x)^3}{3} + \frac{k(a-x)^4}{12}\right]_0^a$ | | M1A1 |
| | $k\left(\frac{a^2a^2}{2} - \frac{2aa^3}{3} + \frac{a^4}{4}\right) = 1.5$ or $\left[\frac{ka(a)^3}{3} - \frac{k(a)^4}{12}\right]_0^a = 1.5$ or $ka^4 = 18$ oe | | dM1 |
| | $\frac{ka^4}{ka^3} = 6$ or $\frac{18}{3} = 6$ $[\therefore a = 6]$ | | A1cso |
| | | | (4) |
| (c) | $F(x) = \frac{1}{72}\left(36x - 6x^2 + \frac{x^3}{3}\right)$ | $\frac{1}{72}\left(36x - 6x^2 + \frac{x^3}{3}\right) = 0.5$ oe | M1 |
| | F(1.15)(= 0.47…) and F(1.25) (= 0.5038…) | 1.2377… | M1 |
| | F(1.15) = awrt 0.47, F(1.25) = awrt 0.504 (0.47(18…) < 0.5 < 0.503(8…)) therefore the median is **1.2** to 1 decimal place. | therefore the median is **1.2** to 1 decimal place. | A1 |
| | | | (3) |
| | | | **Total 10** |

| Notes | | |
|---|---|---|
| (a) | **M1** | Integrating f($x$) at least 1 term correct. For M1 allow $\frac{\pm k(a-x)^3}{3}$ |
| | **A1** | Correct integration (ignore limits) |
| | **A1cso** | Substitute limits and equating to 1 to form one expression in terms of $k$ and $a$ leading to $ka^3 = 3$ |
| (b) | **M1** | Indicating that they are integrating $xf(x)$ with an attempt at integrating $x^n \rightarrow x^{n+1}$ |
| | **A1** | Correct integration |
| | **dM1** | (dep on previous M1). Substitute limits and equating to 1.5 to form a 2nd expression in terms of $k$ and $a$ |
| | **A1cso** | Correct method shown to solve their 2 equations to eliminate $k$ and show $a$=6 |
| | | |
| (c) | **M1** | Finding correct F($x$). Allow $F(x) = 1 - \frac{(6-x)^3}{216}$ but $F(x) = \frac{(6-x)^3}{216}$ is M0<br>Allow in terms of $k$ for this mark |
| | **M1** | For attempting their F(1.15) and their F(1.25) or a suitable tighter interval **or** for 'solving' cubic leading to a value awrt 1.24 |
| | **A1** | Both correct values and correct conclusion (allow $x$ = 1.2) **or** awrt 1.24 and correct conclusion (allow $x$ = 1.2).<br>Allow change of sign argument if they have subtracted 0.5 (i.e. – 0.028… < 0 < 0.0038…). |
| | | |

| Question Number | Scheme | Marks |
|---|---|---|
| 5(a) | U[0, 3] | M1 |
| | $\frac{3-1.8}{3} = 0.4$ | A1 |
| | | (2) |
| (b) | $X^2 = W^2 + (3-W)^2$ | M1 |
| | $X^2 = W^2 + 9 + W^2 - 6W \quad \Rightarrow \quad X^2 = 2W^2 - 6W + 9$ | A1 |
| | | (2) |
| (c) | E($W$) = 1.5 | B1 |
| | Var($W$) = $\frac{9}{12} = \frac{3}{4}$ | B1 |
| | E($W^2$)= "$\frac{3}{4}$" + "1.5"$^2$ | M1 |
| | $E(W^2) = 3$ | A1 |
| | So E($X^2$) = $2\times"3"-6\times"1.5"+9 = 6$ | M1A1 |
| | | (6) |
| (d) | $P(X^2 > 5) = P\left(2W^2 - 6W + 4 > 0\right)$ | M1 |
| | $= P\left((2W-2)(W-2) > 0\right)$ | M1 |
| | $= P(W > 2) + P(W < 1)$ | dM1 |
| | $= \frac{2}{3}$ oe | A1 |
| | | (4) |
| | | **Total 14** |

**Notes**

| | | | |
|---|---|---|---|
| (a) | **M1** | Writing or using the correct distribution Allow: $\frac{1.8}{3}$ for M1A0 | |
| | **A1** | 0.4 oe | |
| (b) | **M1** | Using Pythagoras to find the length Note: $X^2 = W^2 + (W-3)^2$ scores M1A0 | |
| | **A1** | Brackets multiplied seen leading to $X^2 = 2W^2 - 6W + 9$ with no incorrect working | |
| (c) | **B1** | 1.5 | |
| | **B1** | Var($W$) = 0.75 | Using integration: $E(W^2) = \int_0^3 \frac{1}{3} w^2 \, dw$ (ignore limits) |
| | **M1** | Writing or using $E(W^2) = Var(W) + [E(W)]^2$ | $\left[\frac{1}{9} w^3\right]_0^3$ (correct integration with correct limits) |
| | **A1** | 3 | |
| | **M1** | Use of $E(X^2) = 2E(W^2) - 6E(W) + 9$ with their values. | |
| | **A1** | 6 An answer of 6 from correct working implies all previous marks. | |
| (d) | **M1** | For realising they need to find the probability of $2W^2 - 6W + 4 > 0$ (condone =) | |
| | **M1** | Solving their 3-term quadratic ($W$ = 1 and $W$ = 2 implies 1st two M marks) | |
| | **dM1** | (dep on 2nd M1) Realising they need to add the 2 outer areas | |
| | **A1** | awrt 0.667 | |

| Question Number | Scheme | Marks |
|---|---|---|
| 6(a) | Taking a random sample is quicker/cheaper/easier (compared to asking all of the youth club members). | B1 |
| | | (1) |
| (b) | A list/register/database of all the youth club members | B1 |
| | | (1) |
| (c) | The members | B1 |
| | | (1) |
| (d) | $p^2 = \frac{25}{64}$ | M1 |
| | $p = \frac{5}{8}$ | A1 |
| | $"\frac{5}{8}" + q + r = 1$ or $2qr = \frac{1}{16}$ or $\frac{25}{64} + 2"\frac{5}{8}"q + 2"\frac{5}{8}"r + q^2 + \frac{1}{16} + r^2 = 1$ | B1 |
| | Any two equations from above | B1 |
| | $\frac{3}{8}q - q^2 = \frac{1}{32}$ | dM1 |
| | $q = \frac{1}{4}$ | A1 |
| | $\mathrm{P}(M = 50) = \frac{1}{4} \times \frac{1}{4} = \frac{1}{16}$ * | A1cso* |
| | | (7) |
| | | **Total 10** |

**Notes**

| | | |
|---|---|---|
| (a) | **B1** | Any one of the given reasons. Ignore extraneous non-contradictory reasons. |
| (b) | **B1** | Idea of list(oe). Need all (oe) (eg complete list) and members. |
| (c) | **B1** | The members/a member |
| (d) | **M1** | Correct method, may be implied |
| | **A1** | $p = \frac{5}{8}$ or $\mathrm{P}(X = 20) = \frac{5}{8}$ |
| | **B1** | One equation in $q$ and $r$ from use of $p + q + r = 1$, $\mathrm{P}(M = 60)$ or $\sum \mathrm{P}(M{=}m) = 1$ see Note (allow ft on their value of $p$) |
| | **B1** | Two correct equations in $q$ and $r$ Some will substitute directly into the third equation so may see: $\frac{25}{64} + \frac{5}{4}q + \frac{5}{128q} + q^2 + \frac{1}{16} + \frac{1}{1024q^2} = 1$ which is correct and scores B1B1 |
| | **dM1** | (dep on 1st B1) Correct method to solve simultaneous equation leading to a probability for $q$ or $r$ (may be implied by $q = \frac{1}{4}$ or $r = \frac{1}{8}$ provided B1B1 scored) |
| | **A1** | Correct probability for $q$ (dependent on all previous marks in part (d)) |
| | **A1cso*** | Correct solution with use of $\mathrm{P}(M = 50) = q^2$ and all previous marks awarded. |
| | | |
| | **Note:** | |

| $m$ | 20 | 35 | 45 | 50 | 60 | 70 |
|---|---|---|---|---|---|---|
| P($M$=$m$) | $\frac{25}{64}$ | $2pq$ | $2pr$ | $q^2$ | $\frac{1}{16}$ | $r^2$ |

$$\frac{25}{64} + 2pq + 2pr + q^2 + \frac{1}{16} + r^2 = 1$$