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INTERNATIONAL A LEVEL MATHEMATICS • STATISTICS 2 (WST02)

# Statistics 2 Practice Paper 1

Mark Scheme

**AIMING FOR B**

Written in the style of the Pearson Edexcel International Advanced Level paper (WST02/01) • 75 marks

Every question marked line by line the way an examiner marks it, with notes on the common errors

**Mark every line, not just the answer.** Method marks are given for a correct method even when the final answer is wrong. If you lost marks, find the *first* line where your working differs from the scheme. That is the thing to fix.

| Code | Meaning |
|---|---|
| **M1** | Method mark: for knowing a correct method and attempting to apply it. Small slips in the working do not lose this mark. |
| **dM1** | Dependent method mark: can only be given if the method mark before it has been given. |
| **A1** | Accuracy mark: for a correct answer or line of working. It depends on the method mark before it. |
| **B1** | Independent mark: for a correct result or statement, whatever method was used. |
| * | The answer is given in the question. Every step must be shown, and the answer must follow from correct working (cso). |
| **cao / cso** | Correct answer only / correct solution only, with no errors anywhere in the working. |
| **ft / oe** | Follow through from your own earlier answer / or any correct equivalent form. |
| **awrt** | Answers which round to the value given, so $-0.9637\ldots$ earns "awrt $-0.964$". |

**Tables, tests and context.** Write the distribution with its parameters, such as $X \sim \mathrm{B}(20, 0.3)$, and a probability statement before every table value: values from the binomial and Poisson tables are given to 4 decimal places. Hypotheses must use $p$ or $\lambda$, and a test needs a conclusion in the context of the question. For a normal approximation, show the continuity correction and the standardisation.

**Rough grade guide (out of 75):** A* **66** • A **59** • B **50** • C **42**

Based on recent WST02 grade boundaries. Real boundaries change every series, so treat this as a guide, not a grade.

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# What to revise next

Write in your score for each question. Where you dropped marks, tap the chapter to practise ten more exam questions on it.

| Q | What it tested | Marks | Practise it | Score |
|---|---|---|---|---|
| 1 | A binomial model: assumptions, probabilities from the tables, mean and variance | 8 | Ch 1 Binomial Distributions | |
| 2 | Census and sampling frame; the sampling distribution of a total | 9 | Ch 6 Sampling | |
| 3 | A Poisson model, with the rate scaled to a new interval | 10 | Ch 2 Poisson Distributions | |
| 4 | The continuous uniform distribution; a binomial count | 9 | Ch 5 Continuous Uniform<br>Ch 1 Binomial Distributions | |
| 5 | Poisson and normal approximations to a binomial | 11 | Ch 3 Approximations | |
| 6 | One-tailed binomial tests: critical region and a $p$-value | 12 | Ch 7 Hypothesis Testing<br>Ch 1 Binomial Distributions | |
| 7 | A pdf: $k$, the cdf, median, mode and skewness | 16 | Ch 4 Continuous Random Variables | |
| | **Total** | **75** | | |

**Where did the marks go?** If you lost the first marks of a question, the method needs work: go back to that chapter's key skills page. If you lost the final marks, the method is fine and the gap is usually the wrong cumulative value from the tables, a missing continuity correction, or a conclusion not written in context. In Statistics 2 a test conclusion must answer the question that was asked, in its own words.

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## Question 1

8 marks

| Part | Scheme | Marks |
|---|---|---|
| (a) | Whether the train is late on one day is independent of other days<br>The probability of being late is the same (0.15) every day<br>*Each assumption must mention the train or the days. "Fixed number of trials" is given, so it earns nothing here.* | B1<br>B1<br>(2) |
| (b) | $X \sim \text{B}(20, 0.15)$: $\text{P}(X = 3) = \binom{20}{3}(0.15)^3(0.85)^{17}$<br>0.243 | M1<br>A1<br>(2) |
| (c) | $\text{P}(X \leqslant 5) - \text{P}(X \leqslant 1) = 0.9327 - 0.1756$<br>0.7571<br>*$X < 6$ means $X \leqslant 5$, and $X \geqslant 2$ means subtracting $\text{P}(X \leqslant 1)$.* | M1<br>A1<br>(2) |
| (d) | Mean $= 20 \times 0.15 =$ 3<br>Variance $= 20 \times 0.15 \times 0.85 =$ 2.55 | B1<br>B1<br>(2) |
| | | **Total for Question 1: 8 marks** |

## Question 2

9 marks

| Part | Scheme | Marks |
|---|---|---|
| (a) | Advantage: every customer's view is included (an accurate, unbiased result)<br>Disadvantage: time-consuming or expensive, or hard to reach every customer | B1<br>B1<br>(2) |
| (b) | A list of the café's customers, e.g. from a loyalty card scheme | B1<br>(1) |
| (c) | Lists the possible totals 4, 5, 6, 7, 8 and 10<br>Probabilities as products, with a factor 2 for mixed pairs, e.g. $\text{P}(T = 5) = 2 \times 0.5 \times 0.3$<br>$\text{P}(T = 4) = 0.25$, $\text{P}(T = 5) = 0.3$<br>$\text{P}(T = 6) = 0.09$, $\text{P}(T = 7) = 0.2$<br>$\text{P}(T = 8) = 0.12$, $\text{P}(T = 10) = 0.04$<br>*The six probabilities should add to 1: a useful check.* | B1<br>M1<br>A1<br>A1<br>A1<br>(5) |
| (d) | $0.2 + 0.12 + 0.04 =$ 0.36 | B1<br>(1) |
| | | **Total for Question 2: 9 marks** |

## Question 3

10 marks

| Part | Scheme | Marks |
|---|---|---|
| **(a)** | Calls arrive independently (singly), at random<br>Calls arrive at a constant average rate<br>*Both reasons must be about calls.* | **B1**<br>**B1**<br>**(2)** |
| **(b)** | $X \sim \text{Po}(3)$: $\text{P}(X = 4) = \dfrac{\text{e}^{-3}3^4}{4!}$<br>$\boxed{0.168}$ | **M1**<br>**A1**<br>**(2)** |
| **(c)** | $Y \sim \text{Po}(9)$<br>$1 - \text{P}(Y \leqslant 7) = 1 - 0.3239$<br>$\boxed{0.6761}$ | **B1**<br>**M1**<br>**A1**<br>**(3)** |
| **(d)** | $W \sim \text{Po}(6)$<br>$\text{P}(W \leqslant 9) - \text{P}(W \leqslant 4) = 0.9161 - 0.2851$<br>$\boxed{0.6310}$ | **B1**<br>**M1**<br>**A1**<br>**(3)** |
| | | **Total for Question 3: 10 marks** |

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## Question 4

9 marks

| Part | Scheme | Marks |
|---|---|---|
| (a) | $X \sim \text{U}[0,40]$: $\dfrac{30-12}{40}$ | M1 |
| | $\boxed{0.45}$ | A1 |
| | | (2) |
| (b) | $\text{E}(X) = \boxed{20}$ | B1 |
| | $\text{Var}(X) = \dfrac{(40-0)^2}{12}$ | M1 |
| | $\boxed{133}$ (or $\frac{400}{3}$) | A1 |
| | *Using $(b-a)^2$ without dividing by 12 scores M0.* | |
| | | (3) |
| (c) | Shorter piece less than 8 cm: $X < 8$ or $X > 32$ | M1 |
| | $\dfrac{16}{40} = \boxed{0.4}$ | A1 |
| | | (2) |
| (d) | $\text{B}(4, 0.4)$: $4 \times 0.4 \times 0.6^3$ | M1 |
| | $\boxed{0.3456}$ | A1 |
| | | (2) |
| | | **Total for Question 4: 9 marks** |

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## Question 5

11 marks

| Part | Scheme | Marks |
|---|---|---|
| **(a)** | $X \sim \text{B}(200, 0.02)$, approximated by Po(4) | **M1** |
| | $\lambda = 200 \times 0.02 = 4$ | **A1** |
| | $\text{P}(X > 6) = 1 - \text{P}(X \leqslant 6) = 1 - 0.8893$ | **M1** |
| | $\boxed{0.1107}$ | **A1** |
| | | **(4)** |
| **(b)** | $n$ is large and $p$ is small (so $np$ is small) | **B1** |
| | | **(1)** |
| **(c)** | $Y \sim \text{B}(150, 0.4)$ approximated by a normal distribution | **M1** |
| | Mean 60 and variance 36 | **A1** |
| | Continuity correction: $\text{P}(Y > 66) = \text{P}(Y \geqslant 67) \approx \text{P}(W > 66.5)$ | **M1** |
| | Standardises: $z = \dfrac{66.5 - 60}{6} = 1.08$ | **M1** |
| | $1 - 0.8599$ | **A1** |
| | $\boxed{0.1401}$ | **A1** |
| | *Without the continuity correction, $z = 1$ and the answer is 0.1587: this loses the second M1 and both A marks after it.* | |
| | | **(6)** |
| | | **Total for Question 5: 11 marks** |

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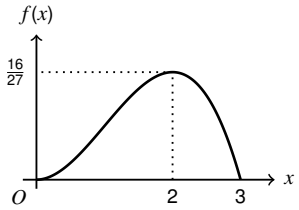
## Question 6

12 marks

| Part | Scheme | Marks |
|---|---|---|
| **(a)** | $H_0 : p = 0.3,\ H_1 : p < 0.3$ | **B1**<br>**(1)** |
| **(b)** | $X \sim B(20, 0.3)$ under $H_0$<br>$P(X \leqslant 2) = 0.0355$ and $P(X \leqslant 3) = 0.1071$<br>$\boxed{X \leqslant 2}$ | **M1**<br>**M1**<br>**A1**<br>**(3)** |
| **(c)** | $\boxed{0.0355}$ (or 3.55%) | **B1**<br>**(1)** |
| **(d)** | 3 is not in the critical region (do not reject $H_0$)<br>Insufficient evidence to support the gardener's belief that fewer than 30% flower in their first year | **M1**<br>**A1**<br>**(2)** |
| **(e)** | $H_0 : p = 0.3,\ H_1 : p > 0.3$<br>$Y \sim B(25, 0.3)$: $P(Y \geqslant 12) = 1 - P(Y \leqslant 11)$<br>$= 1 - 0.9558 = 0.0442$<br>$0.0442 < 0.05$, so reject $H_0$ (significant)<br>There is evidence to support the supplier's claim that more than 30% of plants flower with the fertiliser<br>*The critical region method also scores:* $P(Y \geqslant 12) = 0.0442 < 0.05$ *and* $P(Y \geqslant 11) = 0.0978$*, so the critical region is* $Y \geqslant 12$ *and 12 lies in it.* | **B1**<br>**M1**<br>**A1**<br>**M1**<br>**A1**<br>**(5)** |
| | | **Total for Question 6: 12 marks** |

## Question 7

16 marks

| Part | Scheme | Marks |
|---|---|---|
| (a) | $\int_0^3 kx^2(3-x)\,\mathrm{d}x = 1$ | M1 |
| | $k\left[x^3 - \frac{x^4}{4}\right]_0^3 = 1$ | A1 |
| | $k\left(27 - \frac{81}{4}\right) = \frac{27k}{4} = 1$, so $k = \frac{4}{27}$ | A1* |
| | | (3) |
| (b) |  | B1 |
| | A curve from the origin, rising then falling, with a single maximum | |
| | Zero at $x = 0$ and at $x = 3$, maximum at $x = 2$ | B1 |
| | | (2) |
| (c) | $\mathrm{F}(x) = \int_0^x \frac{4}{27}(3t^2 - t^3)\,\mathrm{d}t$ | M1 |
| | $= \frac{4x^3 - x^4}{27}$ | A1 |
| | $\mathrm{F}(x) = 0$ for $x < 0$ and $\mathrm{F}(x) = 1$ for $x > 3$ | B1 |
| | All three parts correct, with consistent inequalities | A1 |
| | | (4) |
| (d) | $\mathrm{F}(m) = 0.5$: $\frac{4m^3 - m^4}{27} = \frac{1}{2}$ | M1 |
| | $8m^3 - 2m^4 = 27$, so $2m^4 - 8m^3 + 27 = 0$ | A1* |
| | | (2) |
| (e) | Substitutes: $1.8 \to 1.339$ and $1.9 \to -1.808$ (or $\mathrm{F}(1.8) = 0.4752$ and $\mathrm{F}(1.9) = 0.5335$) | M1 |
| | Change of sign (or values either side of 0.5), so $1.8 < m < 1.9$ | A1 |
| | | (2) |
| (f) | $f'(x) = \frac{4}{27}(6x - 3x^2) = 0$ | M1 |
| | $x = 2$ (rejecting $x = 0$): mode = 2 | A1 |
| | | (2) |
| (g) | Negative skew, since median < mode (or mean 1.8 < median < mode). | B1 |
| | | (1) |
| | | Total for Question 7: 16 marks |

**TOTAL FOR PAPER: 75 MARKS**